الهيئة العامة للطيران المدني
GENERAL CIVIL AVIATION AUTHORITY

United Arab Emirates

Air Accident Investigation Sector

Serious Incident

- Final Report -

AAIS Case Nº: AIFN/0010/2017

Descent below Cleared Altitude during Approach and FMS not reconfigured following a reset during the Second Approach

Operator:	Emirates
Make and Model:	Airbus A380-861
Nationality and Registration:	The United Arab Emirates, A6-EEZ
Place of Occurrence:	Domodedovo International Airport, Moscow
State of Occurrence:	Russian Federation
Date of Occurrence:	10 September 2017

This Investigation was conducted by the Air Accident Investigation Sector of the United Arab Emirates pursuant to Civil Aviation Law No. 20 of 1991, in compliance with Air Accident and Incident Investigation Regulations, and in conformance with the requirements of Annex 13 to the Convention on International Civil Aviation.

This Investigation was conducted independently and without prejudice. The sole objective of the investigation is to prevent future aircraft accidents and incidents. It is not the purpose of this activity to apportion blame or liability.

The Air Accident Investigation Sector of the United Arab Emirates issued this Final Report in accordance with National and International Standards and best practice. Consultation with applicable stakeholders, and consideration of their comments, took place prior to the publication of this Report.

The Final Report is publicly available at:

http://www.gcaa.gov.ae/en/epublication/pages/investigationReport.aspx

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Occurrence Brief

AAIS Case Nº:	AIFN/0010/2017
Operator/owner:	Emirates
Aircraft make and model:	Airbus A380-861
Registration mark:	A6-EEZ
MSN:	0158
Number and type of engines:	Four, Alliance (EA) GP7270
Date and time (UTC):	10 September 2017, 1753 UTC
Place:	Domodedovo International Airport, Moscow
Category:	Transport (Passenger)
Persons on board:	448
Injuries:	Nil

Investigation Process

This occurrence was notified by the Operator to the AAIS by phone call to the Duty Investigator (DI) Hotline Number +971 50 641 4667.

The Russian Federal Air Transport Agency (FATA) as the representation of the State of Occurrence delegated the Investigation to the AAIS being the State of Registry and of the Operator.

After the Initial Investigation phase, the occurrence was classified as a 'Serious Incident', and the AAIS assigned an investigation file number, AIFN/0010/2017, to the case.

The AAIS formed an Investigation team led by an investigator-in-charge (IIC). The Bureau d'Enquêtes et d'Analyses (BEA) of French, being the State of Manufacture and Design of the Aircraft, the Federal Air Transport Agency (FATA) of the Russian Federation, being the State of Occurrence, and the National Transportation Safety Board (NTSB) of the United States, being the State of Manufacture of the flight management system (FMS) installed in the Aircraft, were notified of the Incident. The BEA assigned an Accredited Representative who was assisted by Advisers from the Airbus. The FATA provided all required information to the AAIS for the purpose of the Investigation. The NTSB assisted by Advisors from Honeywell (FMS Manufacturer) provided the FMS analysis for the purpose of the Investigation.

Notes:

[1] Whenever the following words are mentioned in this Report with the first letter Capitalized, they shall mean the following:

- (Incident) - this investigated serious incident.
- (Aircraft) - the aircraft involved in this serious incident.
- (Investigation) - the investigation into the circumstances of this serious incident.
- (Operator) - Emirates.
- (Commander) - the commander of the flight.
- (Co-pilot) - the co-pilot of the flight.
- (Report) - this investigation Final Report.

2 Unless otherwise mentioned, all times in this Report are 24-hour clock in Coordinated Universal Time (UTC). UAE Local Time is UTC plus 4 hours.

3 Unless Photos and figures used in this Report are taken from different sources and are adjusted from the original for the sole purpose to improve the clarity of the Report. Modifications to images used in this Report are limited to cropping, magnification, file compression, or enhancement of color, brightness, contrast, or addition of text boxes, arrows or lines.

Abbreviations

A/THR	Autothrust
AAIS	The Air Accident Investigation Sector
AAL	Above aerodrome level
ADD	Acceptable deferred defect
ADIRS	Air data/inertial reference system
A.FLOOR	Alpha floor
AFS	Automatic flight system
AGL	Above ground level
ALT	Altitude
ALT CRZ	Altitude hold of the cruise flight level mode
ALT CRZ*	Altitude capture of the cruise flight level mode
ALT CST	Altitude constraint hold mode
ALT CST*	Altitude constraint capture mode
ALT*	Altitude capture mode
AOC	Air operator certificate
AP	Autopilot
APPR	Approach
APU	Auxiliary power unit
ARC	Airworthiness review certificate
ATC	Air traffic control
ATCCOM	Air traffic control communication
ATPL	Air transport pilot license
AUTO	Automatic
BARO	Barometric
BEA	Bureau d'Enquêtes et d'Analyses of French
BKUP	Backup
BRK	Brake
C/L	Checklist
CAR	Civil aviation regulation
CAT	Category
CCI	Crew critical information
CCQ	Cross crew qualification
CL	Climb detent on thrust levers
CLB	Climb, Climb mode
CONF	Configuration
CONFIG	Configuration

CP	Control panel
CRM	Crew resource management
CRS IN	Inbound course
CRS OUT	Outbound course
CVR	Cockpit voice recorder
DECEL	Decelerate
DES	Descend, Descent
DFDR	Digital flight data recorder
DIR TO	Direct to
DME	Distance measuring equipment
ECAM	Electronic centralized aircraft monitoring
EFB	Electronic flight bag
EFIS	Electronic flight instrument system
EGPWS	Enhanced ground proximity warning systems
ELP	English language proficiency
EWD	Engine and warning display
F/CTL	Flight control
F-G/S	FLS guide slope, FLS guide slope track mode
F-G/S*	FLS guide slope capture mode
F-LOC	FLS localizer, FLS localizer track mode
F-LOC*	FLS localizer capture mode
F-PLN	Flight plan
FAP	Final approach point
FATA	The Federal Air Transport Agency (FATA) of the Russian Federation
FCDC	Flight control data concentrator
FCOM	Flight crew operating manual
FCPC	Flight control primary computers
FCSC	Flight control secondary computers
FCTM	Flight crew techniques manual
FCU	Flight control unit
FD	Flight director
FE	Flight envelope
FG	Flight guidance
FIR	Flight information region
FLS	FMS landing system
FLX	Flexible
FM	Flight management

FMA	Flight mode annunciator
FMC	Flight management computer
FMCS	Flight management computer system
FMS	Flight management system (FMCS and AFS sensors)
fpm	Feet per minute
FPA	Flight path angle
FPPU	Feedback position pick-off unit
FQMS	Fuel quantity and management system
Ft	Feet
GA	Go-around
G/S	Glideslope, Glideslope mode
G/S*	Glide slope capture mode
GA TRK	Go-around track mode
GBAS	Ground based augmentation system
GCAA	The General Civil Aviation Authority of the United Arab Emirates
GLS	GBAS landing system
GPS	Global positioning system
HDG	Heading, Heading mode
ICAO	International Civil Aviation Organisation
IAC	Instrument approach chart
IAF	Initial approach fix
IF	Intermediate fix
ILS	Instrument landing system
IMC	Instrument meteorological condition
INTCP	Intercept point
KCCU	Keyboard and cursor control unit
L	Left side
LAND	Landing, Landing mode
LCT	Line continuation training
LDG	Landing
L/L	Latitude/longitude
LOC	Localizer, localizer track mode
LOC B/C	Localizer back course track mode
LOC B/C*	Localizer back course capture mode
LOC*	Localizer capture mode
LRC	Line release check
LVR	Lever

MAN	Manual
MCP	Mode control panel
MCT	Maximum continuous
MFD	Multi-function display
MHz	Mega hertz
MMR	multimode receiver
MSN	Manufacturer serial number
NAV	Navigation, Navigation mode
NAVAID	Navigation aid
ND	Navigation display
NDB	Non-directional beacon
NTSB	the National Transportation Safety Board of the United States
OFP	Operational flight plan
OIS	Onboard information system
OP CLB	Open climb mode
OP DES	Open descent mode
No.	Number
PAPI	Precision approach path indicator
PB, pb	Pushbutton
PBD	Place/bearing/distance
PB/PB	Place-bearing / place-bearing
PDP	Pilot development program
PERF	Performance
PF	Pilot flying
PFD	Primary flight display
PFR	Post flight report
PM	Pilot monitoring
PPC	Pilot proficiency check
PRIM	Primary flight control and guidance system
R	Right side
REV	Reverse
RQRD	Required
RWY	Runway, Runway mode
RWY TRK	Runway track mode
SEC	Secondary
SEP	Safety equipment procedures
SFCC	Slat/flap control computer

SID	Standard instrument departure
SOP	Standard operating procedure
SPD	Speed
SPLR	Spoiler
SRS	Speed reference system
STAR	Standard terminal arrival
STS	Status
SYS	System
SURV	Surveillance
TAD	Terrain awareness and display
TAWS	Terrain awareness and warning system
TCAS	Traffic alert and collision avoidance system
TERR	Terrain
THR	Thrust
T.O	Takeoff
TOGA	Takeoff/Go-Around
TRK	Track (angle)
TSN	Time since New
TSO	Time since overhaul
UAE	The United Arab Emirates
UTC	Coordinated universal time
VAAP	Approach speed
VFE	Maximum flap extended speed
VLS	Lowest selectable speed
VMC	Visual meteorological condition
V/S	Vertical speed, Vertical speed mode
VD	Vertical display
VDEV	Vertical deviation
VOR	Very high frequency omnidirectional range
WXR	Weather radar
XPDR	Transponder
XTK	Crosstrack

Synopsis

On 10 September 2017, an Emirates Airbus A380-861 Aircraft, registration mark A6-EEZ, operated a scheduled passenger flight EK131, from Dubai International Airport to Domodedovo International Airport, Moscow. There were a total of 448 persons onboard, comprising 422 passengers, two flight crewmembers, and 24 cabin crewmembers.

During approach into Domodedovo International Airport, the Aircraft was cleared for the runway 14R ILS approach when it was on the base leg. The Aircraft descended below its cleared altitude of 500 meters QFE prior to establishing on the localizer. The Radar Controller alerted EK131 to stop the descent. The flight crew then performed a go-around and requested vectors for a second approach. During the go-around, the minimum radio altitude reached was 395 feet above ground level, and EGPWS “Glideslope” and “Terrain Ahead - Pull Up” alerts were activated.

During the second approach as the Aircraft was on the final leg, the flight plan disappeared from the FMS leaving a blank screen. The Commander selected the UUDD14R waypoint using the DIR TO function in the FMS, which resulted in the Aircraft levelling off at 2,600 feet QNH. The flight crew performed a discontinued approach. A third approach to runway 14R was subsequently completed successfully.

The Air Accident Investigation Sector determines that:

(a) The descent below the cleared altitude during the first approach can be explained by an erroneous flight crew perception that the Aircraft would capture the 3° glideslope from above, and by insufficient coordination between the flight crewmembers. After the Co-pilot carried out the *glide interception from above* procedure, he focused on the horizontal position of the aircraft to establish on the localizer and neither of the two pilots maintained a correct awareness of the Aircraft vertical position.

(b) The cause of the discontinued approach on the second approach was the selection by the flight crew of a waypoint using the DIR TO function and after a relatively long discussion between them due to:

- the unavailability of the flight plan on the ND, as the FMS1, reset after the go-around, was not reconfigured by re-sequencing the flight plan as per the SOP; and.
- the Aircraft oscillation around the localizer course.

The Air Accident Investigation Sector identifies the following contributing factors to the Incident:

(a) The expectation of the Co-pilot that Radar Control might not provide the flight crew with vectors to intercept the localizer at an angle of 45 degrees or less when the Aircraft was on the base leg (90-degrees to the final approach track). The provided radar vectors inside the final approach point (FAP) together with the instruction to maintain relatively high speeds until the Aircraft was almost abeam of the initial approach fix (IAF), and the Co-pilot expectation, resulted in an unusually high workload in a dynamic approach phase.

(b) The *glide interception from above* procedure was performed when the Aircraft had not yet established on the ILS localizer for runway 14R. This was not in accordance with the *SOP*.

(c) During the period of when the *glide interception from above* procedure was performed and the go-around, the Aircraft position was initially outside the

azimuthal coverage of the ILS glideslope signal, and when the Aircraft came within azimuthal coverage, it was outside the elevation coverage of the glideslope signal. Consequently, invalid glideslope deviation indications were displayed to the flight crew.

(d) Before performing the *glide interception from above* procedure, the erroneous flight crew representation of the Aircraft position gave them the perception that they were being vectored to a tight approach and that the Aircraft would capture the glideslope from above, led the pilot flying:

- to refer only to the glideslope deviation indication to determine the Aircraft vertical position instead of considering and crosschecking any other available indications (pressure altitude, vertical and navigation displays, and the DME distance table in the approach chart) which would have enabled him to reconsider and validate the Aircraft position; and
- to descend below the cleared altitude and to modify the heading vectors issued by the Air Traffic Controller.

(e) As the Aircraft was descending below 500 meters QFE, the duration of the Radar Controller's instruction to the flight crew "not to descend further" was lengthy and the phraseology used was non-standard for an urgent instruction.

(f) As the flight crew prepared for the second approach, a multi-waypoint sequencing in a row of the flight plan occurred when the crew performed a lateral revision of the flight plan using the DIR TO CRS IN pushbutton as per the SOP at a location where several waypoints satisfied the FMS geometrical waypoint sequencing rules. A real time computation issue caused an automatic reset of FMS1.

(g) After the multi-waypoint sequencing of the flight plan and the FMS1 auto-reset during the second attempted approach, the flight crewmembers omitted to reconfigure the FMS by inserting (adjusting the sequencing of the flight plan) the runway 14R ILS approach. The flight crew did not anticipate that omitting this action, aiming at providing the missed approach route should a go-around need to be performed, would jeopardize the capture of the localizer by the AFS system.

The AAIS issued six recommendations: two to the Operator, two to Air Traffic Control, and two to the Aircraft Manufacturer.

Contents

List of tables

List of figures

1. Factual Information

1.1 History of Flight

On 10 September 2017, an Emirates Airbus A380-861, registration A6-EEZ, operated a scheduled passenger flight EK131, from Dubai International Airport (OMDB[1]) to Domodedovo International Airport (UUDD[2]), Moscow. There were a total of 448 persons onboard the Aircraft, comprising 422 passengers, two flight crewmembers, and 24 cabin crewmembers.

The Commander was the pilot monitoring (PM) and the Co-pilot was the pilot flying (PF).

The Aircraft took off at 1314:22 from runway 30R at OMDB with a take-off weight of approximately 430.7 tons. Figure 1 shows the flight path of the Aircraft from OMDB to UUDD.

Figure 1 – Flight path on google earth – from Dubai (OMDB) to Moscow (UUDD)

The Aircraft was in the Moscow FIR when it started to descend (top of descent) from FL380. The Aircraft followed the FE1D route of the standard terminal arrival (STAR) transitions (figure 2).

Before the Aircraft reached the Aksinyino (AO) NDB[3] point, air traffic control (ATC) vectored the Aircraft for an approach different to that in the operational flight plan. The route, according to the flight plan, began with FE1D as the standard arrival transition, then had AO14K as the standard arrival for the instrument landing system (ILS) and landing on runway 14R (figures 3 and A2.2).

[1] OMDB is the ICAO four letter airport code for Dubai International Airport.

[2] UUDD is the ICAO four letter airport code for Domodedovo International Airport.

[3] A non-directional beacon (NDB) is a radio beacon operating in the MF or LF band-widths. NDBs transmit a signal of equal strength in all directions. The signal contains a coded element which is used for station identification (normally 1-3 letters in Morse Code). NDBs are often associated with Non-Precision Approach procedures. Automatic Direction Finding (ADF) equipment onboard an aircraft uses bearings from NDBs for navigation purposes.

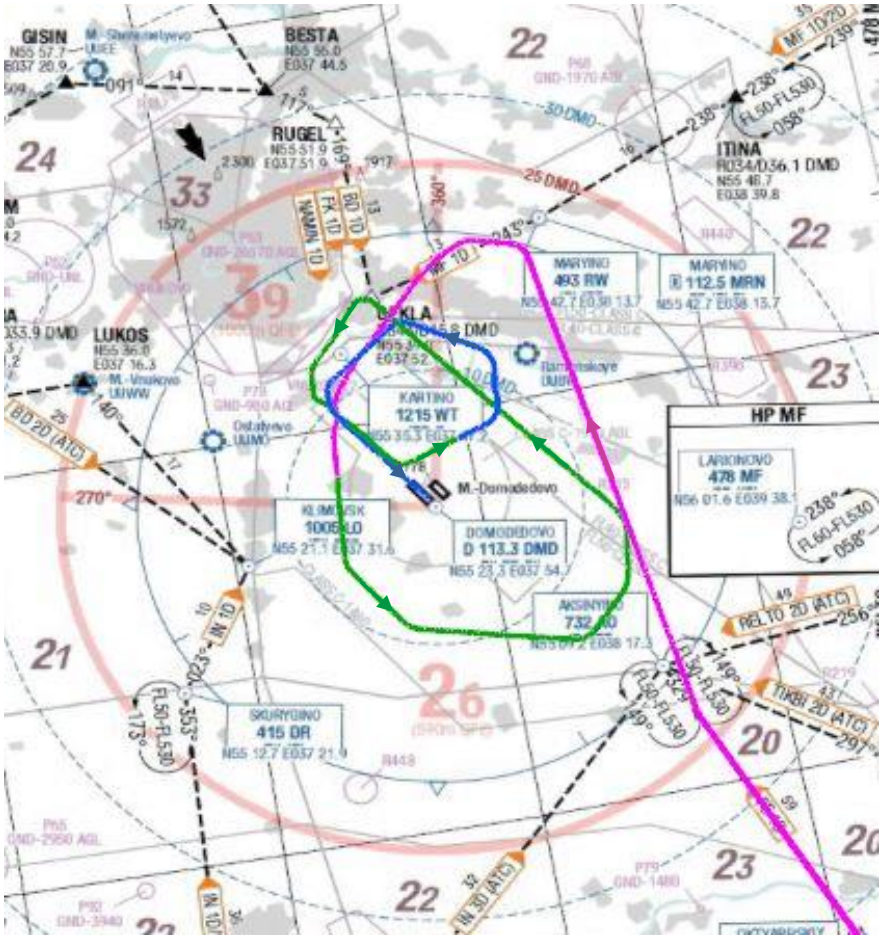


Figure 2 – Approaches and Landing attempts - UUDD Runway 14R STAR Transitions Chart

The flight crew flew one go-around and one discontinued approach and landed on runway 14R from the third approach. The go-around, discontinued and landing are shown in figure 2. The trajectory in magenta depicts the first approach and go-around, the green line illustrates the second approach and discontinued approach, and the third approach and landing is shown by the blue line.

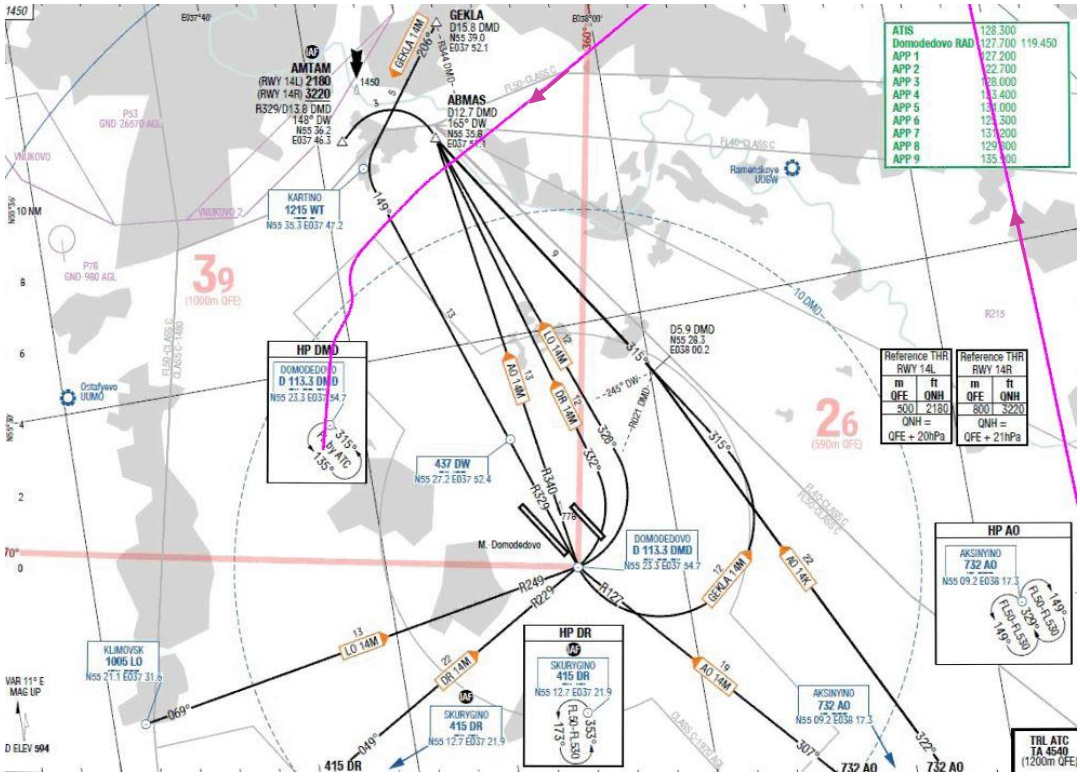


Figure 3 – First Approach and Go-around (magenta line) - UUDD STAR Runways 14L/R Chart

1.1.1 Arrival, First Approach to Runway 14R and Go-around

After passing the Aksinyino (AO) NDB, ATC was providing radar vectoring to EK131 to establish the Aircraft on the runway 14R instrument landing system (ILS). On the base leg, the vectors provided were approximately parallel to the initial approach fix (IAF [4]) – intermediate fix (IF[5]) line as shown in figure 4. The AMTAM waypoint was the IAF point, as illustrated on the ILS 14R chart (figure 4). The flight path of the Aircraft was approximately 2.9 nautical miles shorter to the runway than the localizer interception path through the AMTAM waypoint, as shown on the chart.

At 1751:30, the Radar Controller offered EK131 a descent to 500 meters on a QFE[6] setting (about 2,230 feet on QNH[7] setting) at the flight crew's discretion in order to establish on the localizer. The Commander agreed to descend the Aircraft to 500 meters. At this time, the Aircraft was on a heading of 220 degrees and levelled off at 3,250 feet pressure altitude, and the airspeed was 169 knots.

At 1751:38, the selected altitude setting was changed from 3,300 to 2,300 feet. The Radar Controller acknowledged that the Aircraft was descending to 500 meters and the controller repeated the clearance for the runway 14R ILS on the present heading of 220 degrees to establish the localizer. The Radar Controller requested EK131 to maintain 170 knots as long as possible to avoid minimum separation with traffic behind the Aircraft. EK131 commenced the descent in "open descent[8]" mode.

[4] Initial Approach Fix (IAF) is a fix that marks the beginning of the initial segment and the end of the arrival segment, if applicable. In an RNAV application, this fix is normally defined by a fly-by waypoint.

[5] Intermediate Fix is a fix that marks the end of the initial segment and the beginning of the intermediate segment. In RNAV application, this fix is normally defined by a fly-by waypoint.

[6] QFE is the atmospheric pressure at aerodrome elevation (or at runway threshold).

[7] QNH: the altimeter sub-scale setting to obtain elevation when on ground.

[8] Open descent mode is a vertical selected mode. The autopilot or flight director adjusts the aircraft pitch in order to maintain a speed/Mach target. The autothrust then maintains idle thrust.

At 1752:08, the Radar Controller informed the flight crew that there was no separation issue, and no speed limit instruction was given to the Aircraft. This was acknowledged by EK131. At this time, EK131 was maintaining a 220-degree heading and descending through 3,016 feet pressure altitude at 170 knots airspeed. The selected heading was changed gradually from 220 degrees to approximately 212 degrees, and the Aircraft started to turn left.

At 1752:24, the 170 knots airspeed selected mode was changed to speed managed mode. The target speed was now 143 knots. Consequently, the airspeed reduced gradually.

At 1752:30, the landing gear was down and in locked condition, the slats/flaps were at 'configuration 3', and the speed-brake lever was in the 'arm' position, as configured before.

Nine seconds after the airspeed managed mode was set, at 1752:33, the speed managed mode was set back again to selected mode with an airspeed of 170 knots. The airspeed reached a minimum of 158 knots, and it then increased gradually to the selected airspeed.

At 1752:47, as the Aircraft was about to capture 2,300 feet pressure altitude (1,840 feet radio altitude), the selected altitude setting was changed from 2,300 feet to 3,000 feet (about 700 feet above the initial go-around altitude of 2,240 feet pressure altitude). At this time, the Aircraft was maintaining a heading 212 degrees and descending through 2,320 feet pressure altitude. Three seconds later, the vertical speed setting was selected to a 2,000 feet per minute rate of descent.

At 1752:51, the Radar Controller instructed EK131 to maintain the 220 degrees heading to approach the final approach point (P) at 500 meters, and to contact the Tower on 118.6 megahertz (MHz). The controller provided the QNH of 1015 mbar/hectopascal. The flight crew did not reply to the Radar Controller. At this time, the Aircraft was maintaining a 212-degree heading and descending through 2,236 feet pressure altitude. The airspeed was 162 knots and still increasing gradually to 170 knots.

At 1753:01, the selected heading was changed gradually from 212 to 210 degrees. The Aircraft was now descending through 2,044 feet pressure altitude, and the airspeed had reached the selected 170 knots.

At 1753:08, the Radar Controller instructed the flight crew to maintain 500 meters height at QFE 994 (QNH 1015), and to stop further descent. The Radar Controller repeated this instruction three times. He informed EK131 that the transponder indicated a height of 290 meters and the runway elevation was 180 meters. As the Radar Controller started this communication with the Aircraft, the flaps lever position was changed from configuration '3' to 'full'. At this time, the Aircraft was maintaining a 210 degree heading, descending through 1,720 feet pressure altitude (1,205 feet radio altitude), and the airspeed was 174 knots. At 1753:26, the selected altitude was set to 3,100 feet from 3.000 feet.

At 1753:29, the selected vertical speed setting was changed from -2,000 feet per minute to +2,500 feet per minute.

At 1753:31, the Commander contacted the Radar Controller declaring a go-around. At almost the same time, takeoff/go-around (TOGA) thrust was activated and engine thrust started to increase. The Aircraft was banking to the left through a heading of 197 degrees while descending through 1,084 feet pressure altitude (504 feet radio altitude), and the airspeed was 173 knots.

At 1753:33, the enhanced ground proximity warning system (EGPWS) issued alerts while the Aircraft was still banking to the left, turning through the 197 degree heading and descending through 1,048 feet pressure altitude (474 feet radio altitude), at an indicated airspeed of 172 knots and a distance of 7.3 nautical miles from runway 14R threshold.

The EGPWS alerts began with a two second “glideslope” caution, followed by a terrain awareness and display (TAD) ”Terrain ahead-pull up” warning which lasted for six seconds and ended with a further EGPWS “glideslope” alert lasting one second. The minimum radio altitude reached was 395 feet above ground level, while the EGPWS alerts were active.

The Radar Controller instructed EK131 to continue on its present 200-degree heading, and to climb to 900 meters QFE (3,550 feet QNH). While the Aircraft climbed through 2,128 feet pressure altitude, the controller instructed the flight crew to change heading to 180 degrees. The Radar Controller requested the reason for the go-around and the Commander replied that the approach had been unstable.

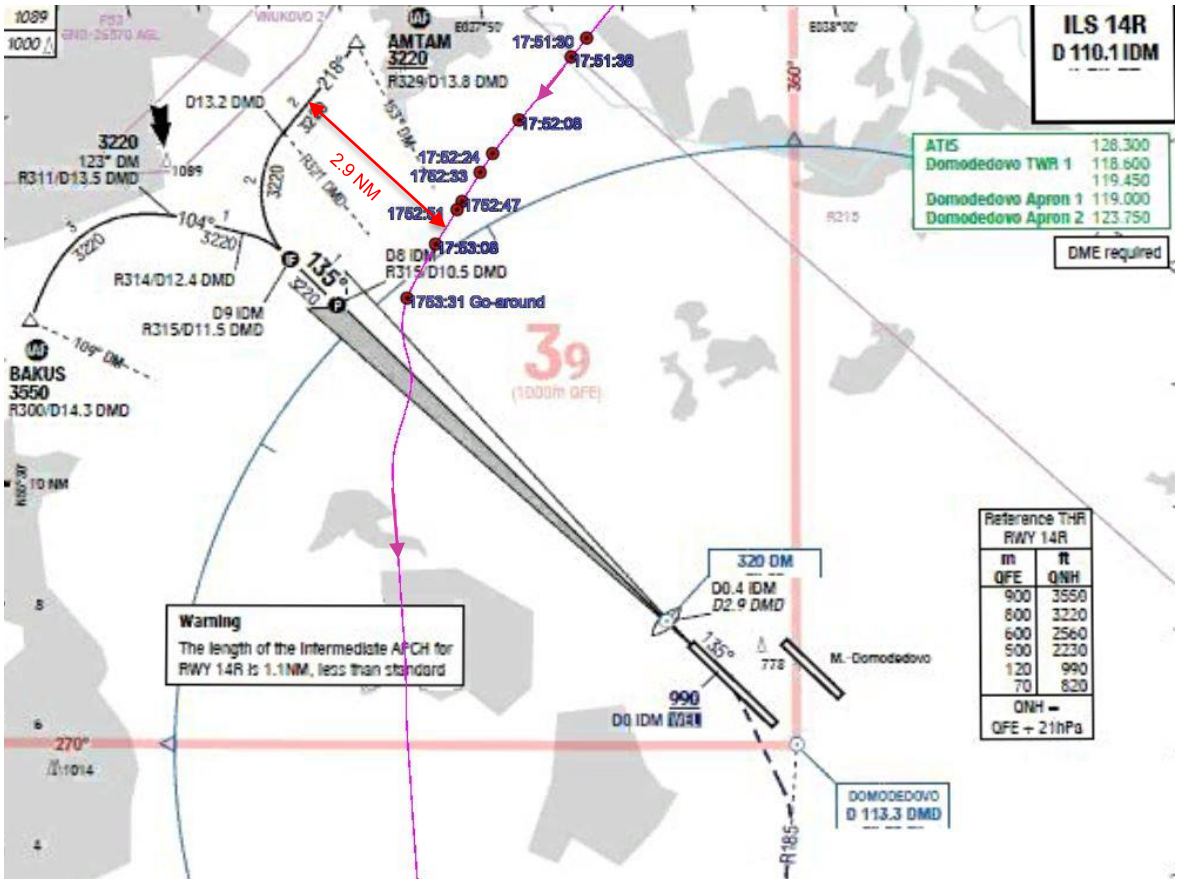


Figure 4 – First Approach and Go-around Flight Path on Instrument Approach Chart (IAC) for ILS 14R

Due to traffic, radar vectoring was provided to EK131 to commence a second approach for landing on runway 14R. The Commander requested a longer final approach, which was agreed by the Radar Controller.

1.1.2 Second Approach of ILS 14R and Discontinued Approach

The radar vectoring for the second approach was such that the flight path passed approximately over position AMTAM, the IAF waypoint for the runway 14R ILS approach (figure 5). The Aircraft then flew through the IF and P[9] points before entering the final approach segment for the precision approach.

[9] The P is the final approach point and is a fix that marks the end of an intermediate segment and the beginning of the final approach segment for a precision approach.

At 1813:31, the Radar Controller provided the clearance for ILS 14R and instructed the flight crew to maintain a 220 degree heading in order to establish on the localizer. No speed limit instruction was provided to EK131. The Radar Controller advised that there was one aircraft on final leg with a separation of approximately 10 kilometers from EK131, which was considered to be sufficient separation. EK131 was maintaining 3,280 feet pressure altitude.

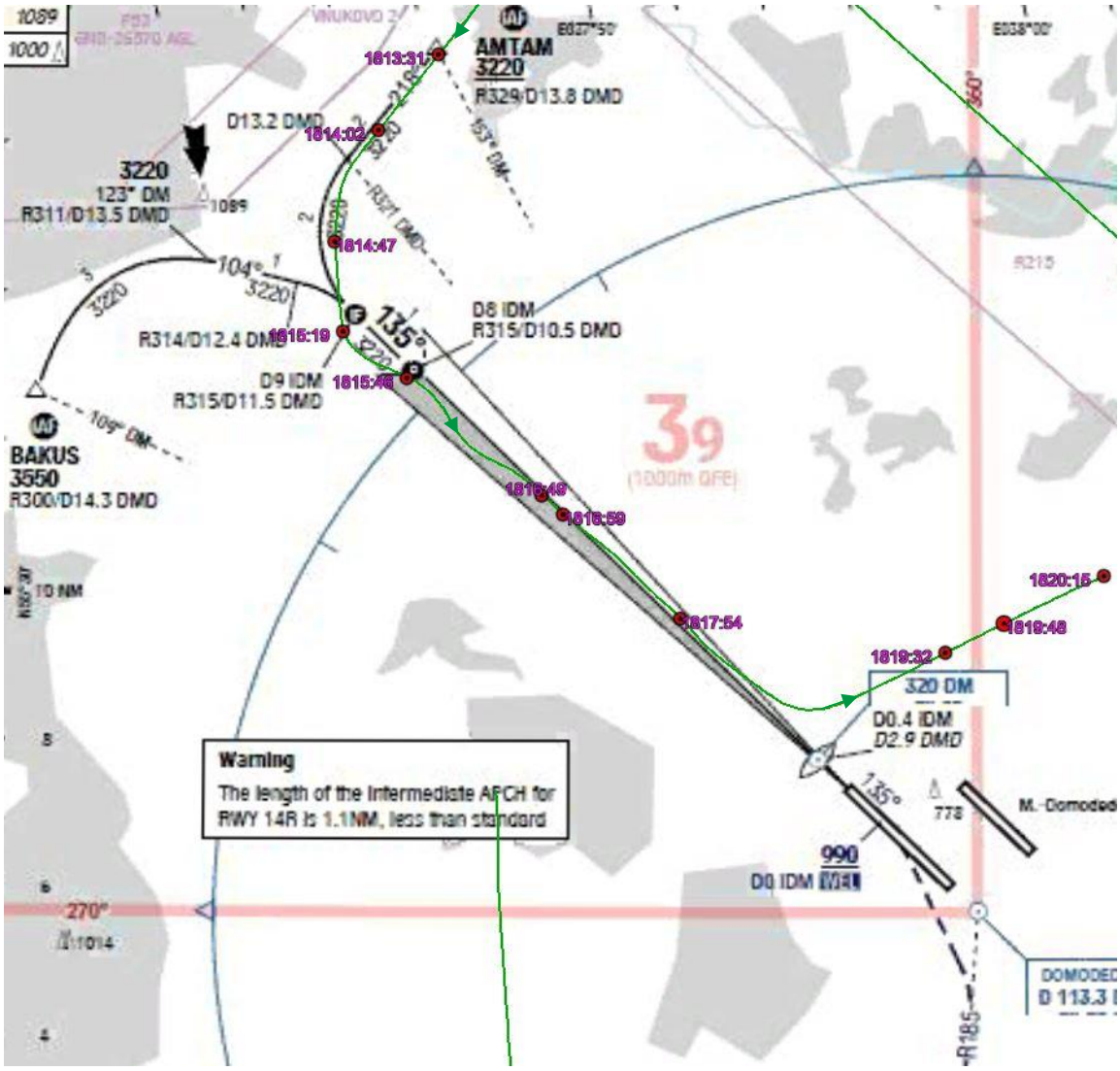


Figure 5 – Second Approach and Discontinued Approach Flight Path on the IAC Chart for ILS 14R

At 1814:02, the Radar Controller asked the flight crew whether EK131 was ready to turn left to establish on the localizer, and the Commander advised that they were ready. The Aircraft then started to turn left while maintaining level. The Radar Controller provided free speed and the Aircraft was instructed to contact Tower control on frequency 118.6 MHz, which was acknowledged by the Commander.

At 1814:47, the Commander contacted the Tower, and the Tower controller instructed the flight crew to continue the approach and the Commander acknowledged. At this time, the Aircraft was turning towards the IF waypoint while maintaining 3,300 feet pressure altitude.

EK131 started to descend when it was near the IF waypoint at 1815:19. The Aircraft went through the P at 1815:46 while descending through 3,128 feet and the airspeed was reducing through 140 knots.

At 1816:49, the Commander radioed the Tower declaring a go-around. The Radar Controller replied and instructed the flight crew to continue the approach to runway 14R.

The Aircraft levelled off at 2,600 feet pressure altitude while maintaining 138 knots airspeed, at 1816:51.

At 1816:59, the Commander contacted the Tower and declared that the Aircraft was going around. However, the Aircraft continued to maintain level at 2,600 feet pressure altitude, since the Aircraft was already at 600 meters QFE, which was the published final missed approach altitude. Hence, TOGA thrust was not activated and the thrust levers were left in the CL detent for the discontinued approach.

At 1817:54, the Tower instructed EK131 to turn left, maintain a 070-degree heading, and contact Radar Control on 127.7 MHz. The Commander acknowledged the instructions, and the Aircraft turned onto a heading of 070 degrees.

At 1819:32, the Tower Controller again reminded the flight crew to contact Radar Control on 127.7 MHz.

The Radar Controller contacted the flight crew at 1819:40, and the Commander replied and informed Radar Control that the Aircraft was maintaining 600 meters QFE on a 070-degree heading.

At 1819:48, the Radar Controller instructed the flight crew to climb to 900 meters and to maintain that level on the same heading. No speed limit instruction was provided to the Aircraft. After several seconds, the Radar Controller revised the clearance and instructed the Aircraft to climb to 800 meters and to maintain that level, which was acknowledged by the flight crew.

At 1820:15, the Radar Controller enquired as to the reason for the go-around. The Commander replied that the go around was due to an unstable approach. While this communication was taking place, the Aircraft started to climb to 800 meters, as instructed. Subsequently, the Commander requested the Radar Controller to provide vectors for a third approach, which was agreed by the Radar Controller.

The Radar Controller enquired one more time as to the reason of the go-around and the Commander answered that the Aircraft was unstable during the final approach.

1.1.3 Third Approach to runway 14R and Landing

The radar vectors provided for the third approach were such that the Aircraft flight path was as shown in figures 2 and 6. The Aircraft did not fly through the IAF point on the path given in the instrument approach chart (IAC) for the runway 14R ILS. Instead, the Aircraft flew closer to the runway on the base leg, on almost the same flight path as on the first attempted approach, but slightly further from the runway.

The Aircraft maintained level at 800 meters QFE on the downwind leg and base leg.

At 1825:20, the Radar Controller enquired as to whether EK131 was ready to continue the ILS approach for runway 14R, and the Commander confirmed that the approach would continue. The airspeed was approximately 173 knots.

At 1826:32, the Radar Controller informed that the flight crew that they were approaching finals, and instructed EK131 to turn left in order to establish on the localizer. The controller also requested the flight crew to report when established, which was acknowledged by the Commander.

At 1827:13, the Radar Controller asked the flight crew to confirm that the Aircraft was fully established on the ILS localizer and glideslope, and the Commander confirmed this. The controller then enquired again, as to whether the flight crew were ready to continue to the final approach, and the Commander confirmed that they were. The Radar Controller then instructed EK131 to contact Tower control on 118.6 MHz, which was acknowledged by the Commander.

At 1828:08, the Tower controller contacted the flight crew, and the Commander replied and informed the controller that the Aircraft was already established on the runway14R ILS. The Tower controller then instructed EK131 to continue the approach. This was acknowledged by the Commander.

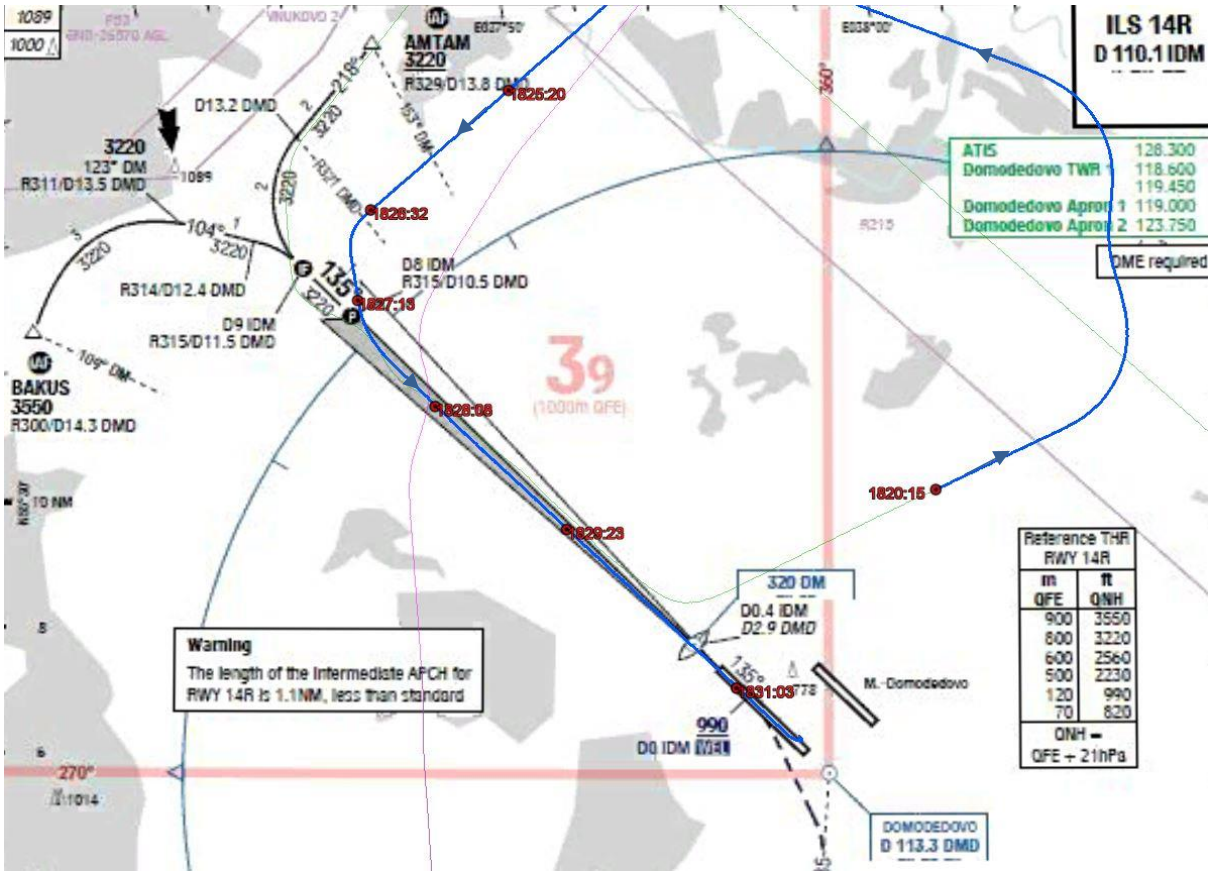


Figure 6 – Third Approach and Landing Path on IAC Chart of ILS 14R

At 1829:23, Tower controller provided the surface wind information. The wind direction was 180 degrees and the speed was 3 meters per second (about 5.8 knots). EK131 was cleared to land on runway 14R. The Commander confirmed the landing clearance.

The Aircraft landed uneventfully on Runway 14R at 1831:03, vacated the runway, and taxied to parking stand 18. The engines were shut down at 1840:13.

More detailed descriptions of the flight history can be found in Appendix 1.

1.2 Injuries to Persons

There were no injuries to persons as a result of this Incident (table 1).

Table 1. Injuries to persons

Injuries	Flight crew	Cabin crew	Other crew onboard	Passengers	Total onboard	Others
Fatal	0	0	0	0	0	0
Serious	0	0	0	0	0	0
Minor	0	0	0	0	0	0
None	2	24	0	422	448	0
TOTAL	**2**	**24**	**0**	**422**	**448**	**0**

1.3 Damage to Aircraft

There was no damage to the Aircraft.

1.4 Other Damage

There was no damage to property, or to the environment.

1.5 Personnel Information

The qualifications of the flight crew were as shown in table 2.

Table 2. Flight crew data

	Commander	Co-pilot
Age	54	39
Type of license	ATPL[10]	ATPL
Valid to	1 October 2019	19 October 2024
Rating	M/E LAND, A310/300 (P2), A330, A340, A380	M/E LAND, A380(P2), B737 300-900 (P2)
Total flying time (hours)	Approximately 18,000 (7,940 with Emirates)	7,280
Total Command on all types (hours)	4855.3	Not Available
Total on this type (hours)	2615.45	700.52
Total twelve months (hours)	830.05	583.6
Total on type the last 28 days	84.32	30.67
Total last 7 days (hours)	17.58	5.75
Total on type last 7 days (hours)	17.58	5.75
Total last 24 hours (hours)	5.75	5.75
Last proficiency check	8 June 2017	14 April 2017
Last line check	31 January 2016	30 December 2016
Medical class	Class 1	Class 1
Valid to	13 July 2018	12 March 2018

[10] ATPL: Air transport pilot license

Medical limitation	VNL[11]	Nil
English language proficiency (ELP)	Level 5	Level 6

The Commander went through and completed CCQ (cross crew qualification) program training from the A330/A340 to the A380 in December 2014, and he underwent Operator required recurrent training and checking thereafter, and most recently, in June 2017.

The Co-pilot held B737-300 and B737-900 type rating as first officer before joining the Operator. After joining Emirates, the Co-pilot completed all required Operator training, and he underwent the Operator required initial training and checking for the A380 in December 2016. His last recurrent training and checking was undergone in April 2017.

Based on the training records, both flight crew had attended the required training, which included glideslope interception from above, as per the *Operations Manual-Part D (OM-D)*.

1.6 Aircraft Information

1.6.1 General

The Airbus A380-861 aircraft is a double-deck, wide-body, four-engine aircraft manufactured by Airbus. It is equipped with four GP7270 turbofan engines manufactured by Engine Alliance LLC.

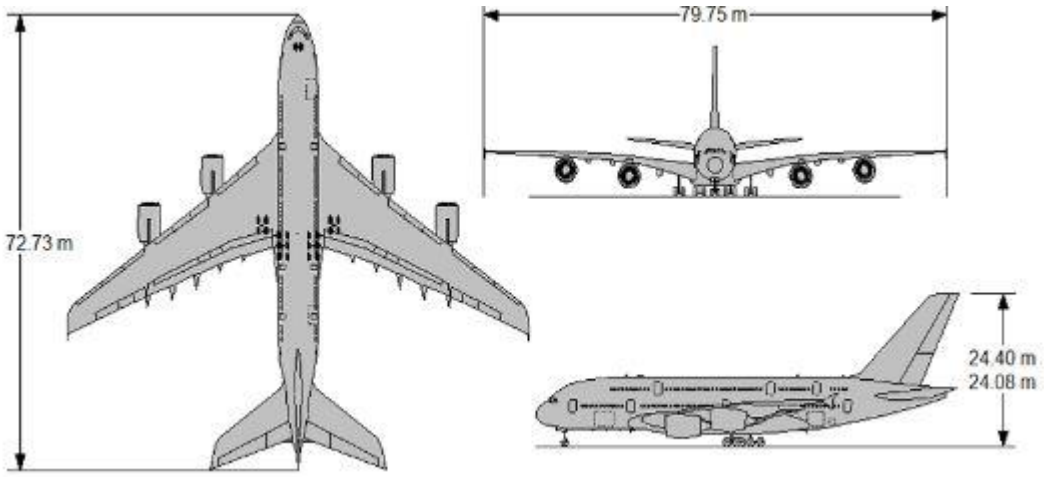


Figure 7 – Three View Drawing

Tables 3 and 4 illustrate the Aircraft and engine data.

Table 3. Aircraft data

Manufacturer:	Airbus
Model:	A380-861
Manufacturer serial number (MSN):	0158
Date of delivery:	24 March 2014
Nationality and registration mark:	United Arab Emirates, A6-EEZ

[11] VNL is a medical limitation code referring to correction for defective near vision, which means that the licence holder should have readily available spectacles that correct for defective near vision as examined and approved by the aero-medical centre or aero-medical examiners.

Name of the Operator:	Emirates
Certificate of airworthiness	
Number:	UAE-COA-0253
Issue date:	22 August 2014
Issuing Authority	The General Civil Aviation Authority of the United Arab Emirates (GCAA)
Valid to:	Valid unless revoked by the GCAA. Current Airworthiness Review Certificate (ARC) was attached to this CoA and valid to 21 August 2018
Certificate of registration	
Number:	UAE-COR-0779
Issue date:	22 August 2014
Issuing authority	The GCAA
Valid to:	Open
Time since new – flight hours:	13,613.78 Hours
Cycles since new:	2212
Last inspection and date:	5 August 2017 (Service Check 2), 21 June 2017 (A-Check)
Time since overhaul – flight hours:	13,114.78 (last Service Check 2), 12,537.48 (A-heck)
Cycles since overhaul:	Not available
Maximum takeoff weight:	510,000 kg
Maximum landing weight:	395,000 kg
Maximum zero fuel weight:	373,000 Kg

Table 4. Engine data

Manufacturer:	Engine Alliance LLC	
	Engine 1	Engine 2
Model:	GP7270	GP7270
Manufacturer serial number (MSN):	P550257	P550421
Date installed on Aircraft:	4 June 2016	4 September 2016
TSN (in hours):	19,521.33	16,081.12
CSN:	3,198	1,818
TSO (in hours):	Not available	Not available
CSO:	Not available	Not available

	Engine 3	Engine 4
Model:	GP7270	GP7270
Manufacturer serial number (MSN):	P550632	P550420
Date installed on Aircraft:	16 April 2017	1 December 2016
TSN (in hours):	4,286.35	16,381.57
CSN:	668	1,805

TSO (in hours):	Not available	Not available
CSO:	Not available	Not available

1.6.2 Automation

The A380 automation provides three levels of assistance: the flight control loop provides immediate assistance via the sidestick; the autopilot loop provides short-term assistance via the automatic flight system control panel (AFS CP); and the flight management provides long-term assistance via the flight management system (FMS).

The flight control (F/CTL), flight envelope (FE), and flight guidance (FG) functions are integrated in each of the three primary flight control and guidance computers (PRIMs). The flight management (FM) function is integrated in each FMS and controlled by three flight management computers (FMCs).

The flight crew interface with the AFS via:

- One AFS control panel
- The AFS CP has a backup, displayed on the multi-function displays (MFD). This backup is referred to as the flight control unit (FCU) backup/AUTO FLT page
- Two MFDs
- Two primary flight displays (PFD)
- Two navigation displays (NDs)
- One sidestick pushbutton on each sidestick
- Four thrust levers, and two autothrust (A/THR) instinctive disconnect pushbuttons.

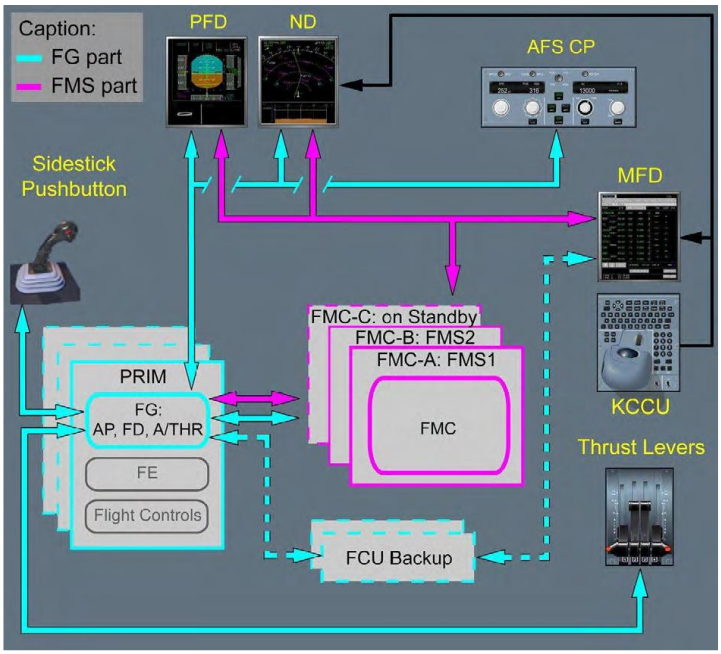


Figure 8 - AFS architecture [Source: Airbus]

Flight guidance

The FG function provides guidance in accordance with flight targets selected by the flight crew, or managed by the FMS. Lateral and vertical guidance is provided, including speed or Mach control, based on defined targets. These targets can be either selected or managed.

The FG operates by using the following modes:

- Autopilot/flight director (AP/FD) lateral modes, which control the aircraft lateral trajectory.
- AP/FD vertical modes, which control either the vertical trajectory, or the Speed or Mach.
- A/THR modes, which control either the thrust, speed, or Mach.

Speed or Mach cannot be simultaneously controlled by the AP/FD and the A/THR.

The FG modes appear on the flight mode annunciator (FMA) of the PFD.

Selected and managed modes

Flight guidance is either selected or managed, therefore, the corresponding modes are also referred to as either selected or managed, as shown in table 5.

Table 5. Guidance modes

Guidance	Managed modes	Selected modes
Lateral	NAV LOC*, LOC LOC B/C*, LOC B/C F-LOC*, F-LOC RWY, RWY TRK GA TRK	HDG, TRACK
Vertical	SRS CLB ALT*, ALT ALT CRZ*, ALT CRZ ALT CST*, ALT CST DES G/S*, G/S F-G/S*, F-G/S TCAS	OP CLB ALT*, ALT ALT CRZ*, ALT CRZ OP DES V/S, FPA
Lateral and vertical (mix mode)	LAND FLARE ROLL OUT	
Speed or Mach	SPEED, MACH with FMS reference	SPEED, MACH with AFS CP reference

The AP/FD vertical mode determines the associated A/THR mode:

- When an AP/FD vertical mode controls a speed or Mach target, the A/THR mode controls thrust.

  The vertical trajectory is a result of speed or Mach, and thrust.

- When an AP/FD vertical mode controls the vertical trajectory, the A/THR mode controls a speed or Mach target.

  Note: During ROLL OUT, and during FLARE with the AP on, the A/THR mode controls thrust at idle.

- If no AP/FD mode is engaged, A/THR engages in SPEED or MACH mode, in order to control a speed or Mach target.

Table 6. Interaction between AP/FD and A/THR

AP/FD		A/THR	
Vertical Modes	**Objectives**	**Modes**	**Objectives**
SRS OP CLB CLB OP DES DES in idle path	Control of Speed or Mach Target	THRUST Modes	Control of Thrust
V/S / FPA ALT*, ALT ALT CST*, ALT CST ALT CRZ*, ALT CRZ DES in geometric path G/S*, G/S F-G/S*, F-G/S TCAS LAND common mode FLARE common mode with FDs engaged only	Control of Vertical Trajectory	SPEED/MACH	Control of Speed or Mach Target
FLARE common mode during autoland	Control of Vertical Trajectory	THRUST Mode	Control of Thrust at Idle
None		SPEED/MACH	Control of Speed or Mach

Selected targets

The flight crew select the targets via the short-term interface, which is the AFS control panel, also called flight control unit (FCU). Then the FG uses these targets to perform the selected guidance.

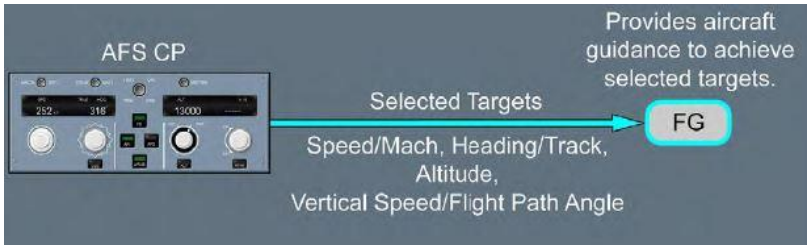


Figure 9. Selected guidance [Source: Airbus]

Managed targets

The FMS manages the flight plan, defined by the flight crew, and provides flight parameters to the FG accordingly.

The flight crew uses the long-term interface in the MFD to prepare the flight plan. The FMS calculates managed targets accordingly. Then the FG uses these targets to perform managed guidance.

Figure 10. Managed guidance [Source: Airbus]

Lateral guidance and vertical guidance can be selected or managed, independently of each other. However, managed vertical guidance is not possible, when selected lateral guidance is used.

Table 7. Combination of selected and managed guidance

		Lateral	
		Selected	**Managed**
Vertical	**Selected**	Yes	Yes
	Managed	No	Yes

Speed or Mach can be either selected or managed, regardless of lateral and vertical guidance.

On the AFS CP, the SPD/MACH, HDG/TRK, V/S / FPA knobs can be turned, pulled, and pushed. This enables the flight crew to:

- Preselect a target by turning the knob
- Engage a mode that will guide the aircraft to a selected target by pulling the knob (Pull)
- Arm or engage a mode that will guide the aircraft to a managed target by pushing the knob (Push).

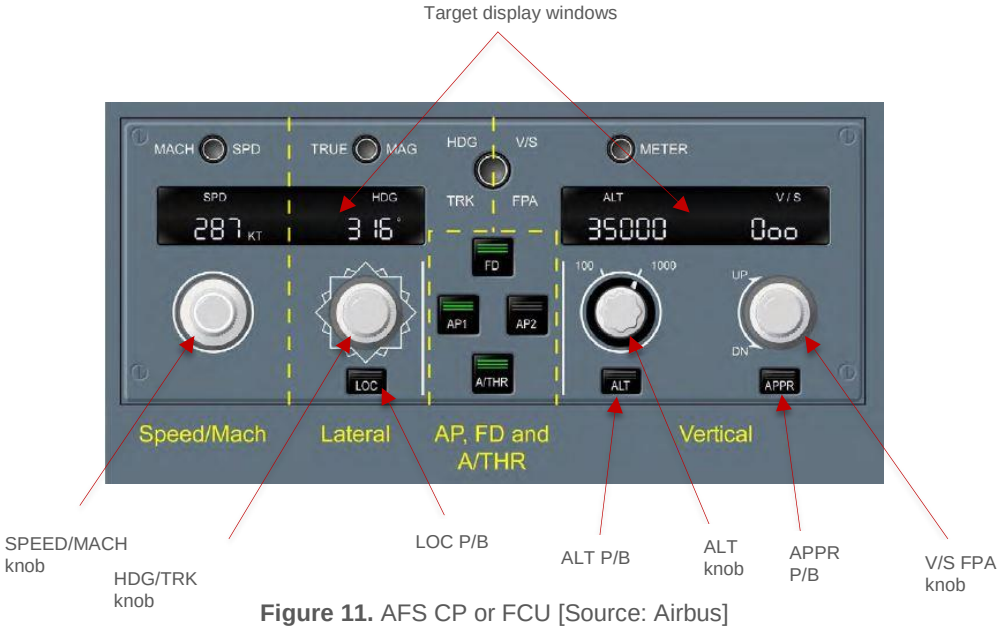


Figure 11. AFS CP or FCU [Source: Airbus]

Primary flight control and guidance computers for flight guidance

The Aircraft was equipped with three primary flight control and guidance computers (PRIMs) for FG. Each PRIM can operate one or both APs, and/or FDs, and/or A/THR. Because each PRIM can operate the A/THR, there are three A/THR channels.

To determine which PRIM will operate the engaged APs, FDs, and A/THR, each PRIM computes its operational capability, taking into account:

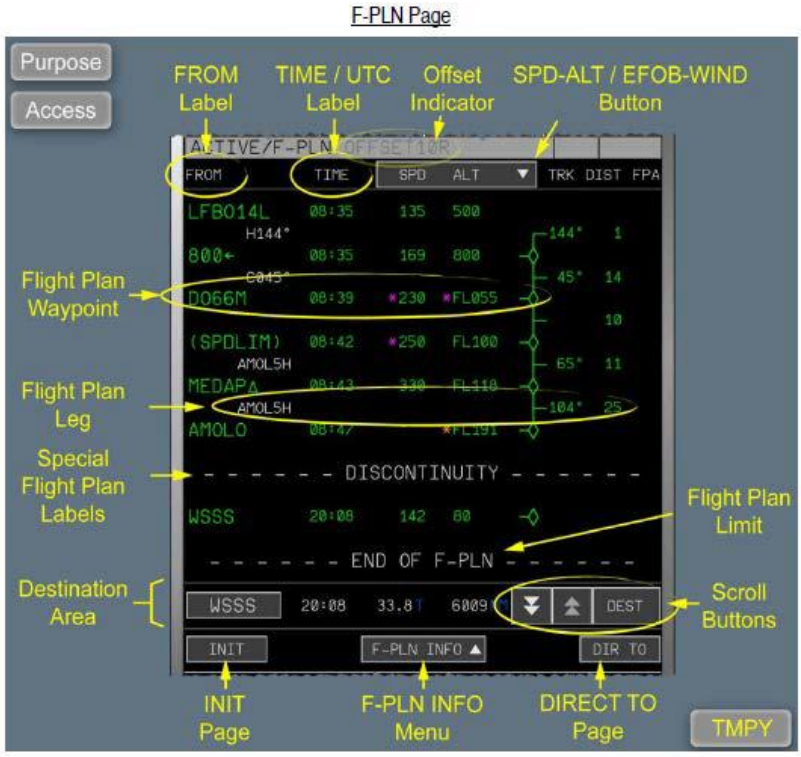
- Manual flight control law capability
- FE, AP, and approach capability
- A/THR capability.

The Master PRIM is the PRIM that has the best operational capability. The Slave 1 PRIM has the second best operational capability, and the Slave 2 PRIM has the third best.

Multi-function displays (MFD)

The MFD displays FMS, ATC communication, surveillance, and FCU backup. The MFD is interactive where the flight crew can navigate through the pages, and can consult, enter or modify the data via the keyboard and cursor control unit (KCCU).

The FMS pages is used to prepare a flight plan (long-term interface) by the flight crew. An example of MFD flight plan (figure 12).



Note: TO waypoint line in white is not represented in the figure above corresponding to flight plan that has been scrolled down

Figure 12 – Example of flight plan page displayed on MFD [Source: Airbus]

DIR TO function

The flight crew uses the direct to (DIR TO) revision to create a direct (great circle) leg from the aircraft present position to:

- A flight plan waypoint

- Any navigation database waypoint, airport, or navigation aid (NAVAID)
- A latitude/longitude (LL), place/bearing/distance (PBD), or place-bearing/ place-bearing (PB/PB) waypoint.

A DIR TO a flight plan waypoint creates a direct leg between the aircraft present position and the selected target waypoint. The flight plan waypoints between the aircraft present position and the selected target waypoint are deleted.

A DIR TO any other waypoint, which is not on the flight plan, creates a direct leg between the aircraft present position and the selected target waypoint, and a flight plan discontinuity between the target waypoint and the former TO waypoint.

If the lateral mode is HDG/TRK or LOC, the NAV mode engages automatically when the DIR TO is inserted.

The flight crew has three options for creating the direct leg:

- DIR TO with abeam points (DIRECT WITH ABEAM), or
- DIR TO with inbound course (CRS IN), or
- DIR TO with outbound course (CRS OUT).

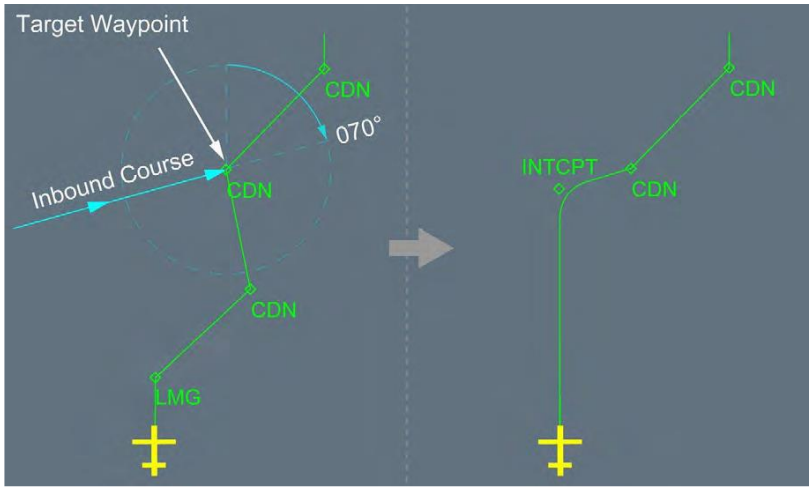
CRS IN option of DIR TO

This option creates a direct leg from the aircraft present position to intercept an inbound course (selected by the flight crew) to the target waypoint.

The track of the direct leg is the current aircraft track.

If the angle between the direct leg and the inbound course is less than 160 °:

- An intercept point (INTCP) is computed
- The lateral HDG mode is engaged and NAV is armed.



Note: The figure above represents the case when the angle condition is satisfied, enabling the intercept point (INTCP) to be computed

Figure 13 – Example of CRS IN of DIR TO displayed on MFD [Source: Airbus]

Flight Director

The flight director (FD) displays guidance orders on the PFDs:

- If no AP is engaged, the flight crew can manually fly the aircraft by following the FD orders.

- If at least one AP is engaged, the flight crew can use the FD to monitor the flight guidance.

There are two FDs, referred to as FD1 and FD2.

- FD1 guidance orders appear on the Captain's PFD.

  FD1 uses data from the systems on the Captain's side:

  - When in managed mode, FD1 guidance orders are computed by using FMS1 data.
  - FD1 uses air data/inertial reference system 1 (ADIRS1) data.

- FD2 guidance orders appear on the First Officer's PFD.

  FD2 uses data from the systems on the First Officer's side:

  - When in managed mode, FD2 guidance orders are computed by using FMS2 data
  - FD2 uses ADIRS2 data.

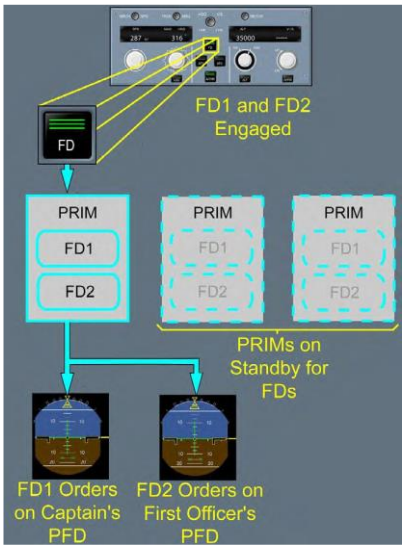


Figure 14. Flight director [Source: Airbus]

The FDs automatically engage on aircraft power-up.

Both FD1 and FD2 manually engage when the flight crew press the FD push button on the AFS CP. If no AP was previously engaged, then HDG or TRACK, and V/S or FPA engage. The FD bars flash for 10 s.

On FD engagement, both FD1 and FD2 engage at the same time.

When the FDs are engaged, the PFDs can display the roll, pitch and yaw bars.

The pitch, roll, and yaw bars respectively indicate the pitch, roll, and yaw FD guidance orders.

Autopilot

The autopilot (AP) stabilizes the Aircraft around its center of gravity; controls the lateral trajectory; controls the vertical trajectory or speed/Mach; Coordinates with the A/THR; and performs automatic landing or go-around.

The AP generates pitch, roll and yaw orders, and nose wheel angle.

There are two APs: AP1 and AP2. Only one operates at a time.

AP1 uses ADIRS1, and AP2 uses ADIRS2.

When the autopilot is engaged, the sidesticks are locked in the neutral position (immediate tactile feedback). Simultaneous input by the flight crew and the autopilot is not possible.

The autopilot can be disconnected instinctively, at any time, by firm pressure on the sidestick.

AP1 and AP2 usually engage separately. In some conditions, the flight crew can engage both at the same time.

When both APs are engaged, AP1 is active, and AP2 is on standby, regardless of the order of AP engagement.

Autothrust

The Aircraft is equipped with autothrust (A/THR) which manages the engine thrust, and can be either armed, active, or disconnected.

The A/THR, when active, can function in two different types of mode:

- SPEED/MACH mode: The A/THR continuously adjusts the thrust in order to maintain a speed/Mach target, e.g. during cruise, and approach.
- THRUST modes: The A/THR controls a fixed thrust, in accordance with the engaged THRUST mode.

The A/THR modes are automatically linked to the AP/FD vertical modes:

- When an AP/FD vertical mode controls the trajectory (e.g. altitude acquire modes, altitude hold modes, V/S / FPA, G/S, F-G/S), the A/THR is in SPEED/MACH mode.
- When an AP/FD vertical mode adjusts the aircraft pitch in order to keep a speed/Mach target (e.g. climb, descent), the A/THR is in THRUST mode.

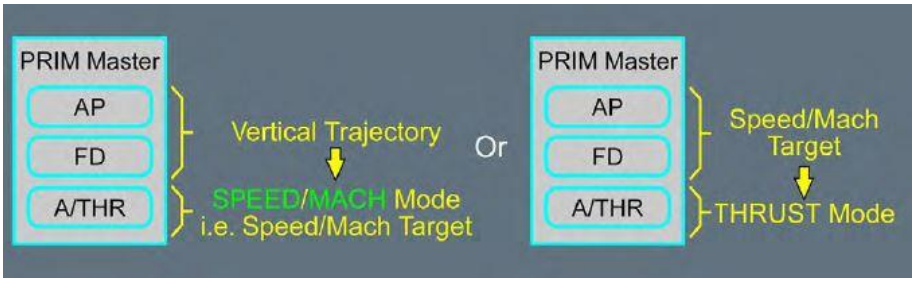


Figure 15 – Interaction of AP/FD and A/THR [Source: Airbus]

The thrust levers are used to:

- Arm, activate, and disconnect the A/THR;
- Engage takeoff and go-around modes;
- Manually control the thrust of each engine, when the A/THR is disconnected; and
- Engage reverse thrust on engines 2 and 3.

The thrust levers have:

- Four detents: 0 (idle), CL, FLX-MCT, TOGA.
- Two instinctive disconnect pushbuttons.

The normal position of the thrust levers is at the CL detent, when all engines are operating.

The A/THR activates, if one of the following occurs:

- The A/THR is armed, and the flight crew set the thrust levers in the active range:

  For all engines operating:

  - Between the idle and CL detents (idle excluded, CL included).
  - TOGA is selected on the T.O. panel of the FMS PERF page, and:
    - At least one thrust lever is on or below the CL detent, and
    - The others are on or below the FLX-MCT detent.
  - FLX is selected on the T.O. panel of the FMS PERF page, and:
    - At least one thrust lever is on or below the CL detent, and
    - The others are below the FLX-MCT detent.

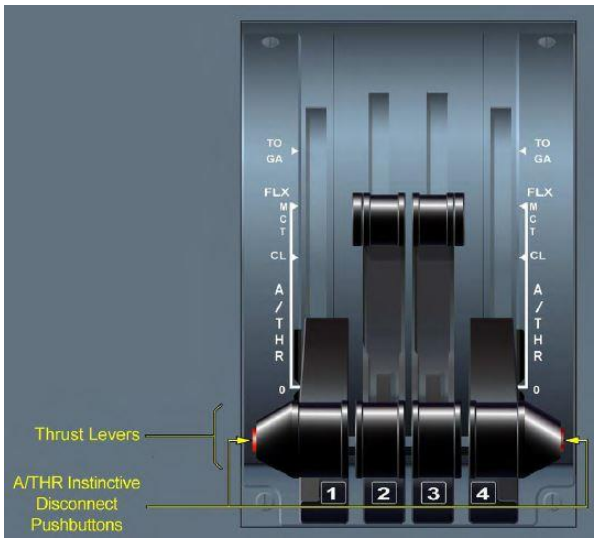


Figure 16 - Thrust Levers [Source: Airbus]

The flight crew also arm the A/THR by engaging a go-around (MAN TOGA) or a soft go-around (MAN GA SOFT): The flight crew set the thrust levers at the TOGA detent. Then in the case of a soft go-around, the flight crew retard the thrust levers to the FLX-MCT detent.

At the TOGA detent, the A/THR controls the thrust at TOGA thrust.

At the FLX-MCT detent when the TOGA detent was previously set (i.e. in the case of soft go-around), the A/THR controls the thrust to target a vertical speed of approximately 2,000 feet per minute (or TOGA if 2,000 feet per minute cannot be reached).

FMA messages when A/THR is armed and active

With at least one thrust lever set to the TOGA detent, MAN TOGA appears on the FMA.

When the thrust lever position is at TOGA and is then moved to the FLX-MCT detent, MAN GA SOFT appears on the FMA.

When the thrust lever position is between CL and TOGA, but not at the CL, FLX-MCT, or TOGA detent, MAN THR appears on the FMA.

When the A/THR is active:

- The FMA displays:
  - The message A/THR on the third line of the fifth column
  - The A/THR mode in green on the first line of the first column.
- The A/THR pushbutton (pb) light is illuminated on the AFS CP.

The flight crew performs a soft go-around by setting the thrust levers to TOGA and then FLX-MCT detent. When the aircraft reaches the thrust reduction altitude, LVR CLB flashes, and the flight crew sets the thrust levers to the CL detent:

- The A/THR activates
- THR CLB appears on FMA.

The soft go-around function is only available with all engines operating.

AP/FD Mode Status and Flight Management Annunciator

For monitoring the AP/FD status, the Aircraft is equipped with flight management annunciator (FMA). The FMA indicates the status of the AP, FD and A/THR and their corresponding operating modes. The PF must monitor the FMA and announce any FMA changes. The flight crew uses the AFS CP or MFD/KCCU to give orders to the AP/FD, and the aircraft is expected to fly in accordance with these orders.

If the aircraft does not fly as expected, and if in managed mode, then select the desired target, or disengage the autopilot, and fly the aircraft manually.

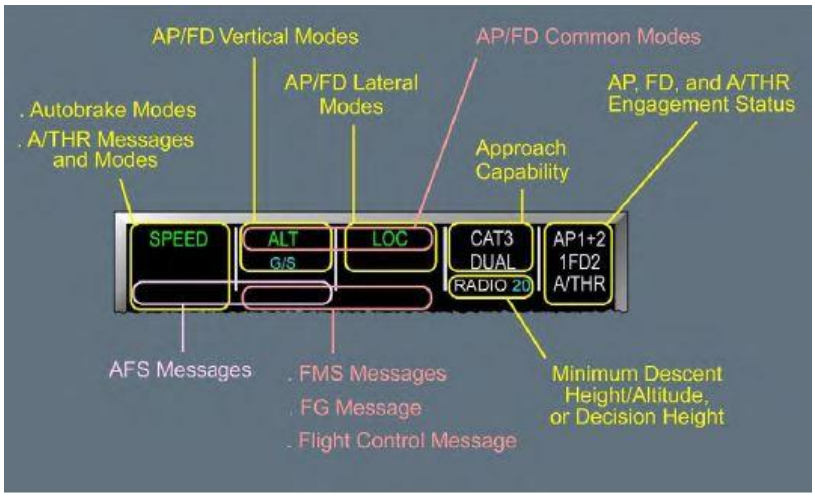


Figure 17. FMA [Source: Airbus]

An AP/FD lateral or vertical mode can be armed, engaged, or disengaged.

When an AP/FD lateral mode is armed, the FMA displays the lateral mode in blue, on the second line of the third column. When an AP/FD lateral mode is engaged, the FMA displays the lateral mode in green, on the first line of the third column.

When an AP/FD vertical mode is armed, the FMA displays the vertical mode in blue, on the second line of the second column. When an AP/FD vertical mode is engaged, the FMA displays the vertical mode in green, on the first line of the second column.

When an AP/FD lateral or vertical mode is disengaged, the FMA does not display the disengaged mode.

An AP/FD common mode can either be engaged or disengaged.

When an AP/FD common mode is engaged, the FMA displays the common mode in green, on the first line of the second and third columns. When an AP/FD common mode is disengaged, the FMA does not display the mode.

When all APs and FDs are disengaged, all AP/FD modes are disengaged.

The AP/FD lateral modes are shown in Table 8.

Table 8. AP/FD lateral modes	
RWY, RWY TRK	Runway mode, Runway track mode
NAV	Navigation mode
HDG, TRACK	Heading mode, Track mode HDG and TRACK are the lateral basic modes.
LOC*, LOC	Localizer capture mode, Localizer track mode
LOC B/C*, LOC B/C	Localizer back course capture mode, Loc back course track mode
F-LOC*, F-LOC	Flight Management System Landing System Localizer capture mode, Flight Management System Landing System Localizer track mode
GA TRK	Go-around track mode

The AP/FD vertical modes are shown in Table 9.

Table 9. AP/FD vertical modes	
SRS	Speed Reference System mode, used during takeoff and go-around SRS TO refer to SRS mode during takeoff, and SRS GA refers to SRS mode during go-around.
CLB	Climb mode
DES	Descent mode
OP CLB	Open Climb mode
OP DES	Open Descent mode
V/S, FPA	Vertical Speed mode, Flight Path Angle mode. V/S and FPA are the vertical basic modes.
ALT*, ALT	Altitude capture mode, Altitude hold mode
ALT CST*, ALT CST	Altitude constraint capture mode, altitude constraint hold mode

ALT CRZ*, ALT CRZ	Altitude capture of the cruise flight level, Altitude hold of the cruise flight level
G/S*, G/S	Glideslope slope capture mode, Glideslope slope track mode
F-G/S*, F-G/S	FLS-G/S capture mode, FLS-G/S track mode
TCAS	AP/FD TCAS mode

Note:

- ALT*, ALT CST*, and ALT CRZ* are referred to as the altitude acquire modes.
- ALT, ALT CST, and ALT CRZ are referred to as the altitude hold modes.

Flight management system

The Aircraft was fitted with FMS L2.1 standard, which is manufactured by Honeywell. The Aircraft was equipped with a FMS computer part number HNP57XAL01X8005, and FMS database EX61709002.

The Flight Management System (FMS) provides:

- Flight planning and navigation information
- Performance calculation, and optimization
- Long-term guidance targets
- Information display on the MFD, ND, and PFD.

The flight crew can create a complete flight plan (**lateral** and **vertical**) in the FMS. The flight crew first selects or creates a basic flight plan, and then inserts fuel, load, and wind information. When all necessary data is added, the FMS computes and displays the track, speed, altitude, time, wind, and fuel predictions that are associated with the flight plan. The flight crew can modify the flight plan at any time.

The FMS tunes the radio navigation aids, and computes the aircraft position and position accuracy.

The FMS provides optimization and flight phase-related performance data.

The FMS sends targets to the FG to guide the aircraft along the inserted flight plan.

FMS information appears on the Multi-Function Displays (MFDs), Navigation Displays (NDs), and Primary Flight Displays (PFDs).

The MFDs and the NDs are interactive display units that are used to enter or modify data, via the Keyboard and Cursor Control Units (KCCUs).

There are two flight management systems:

- The FMS 1, on the Captain's side
- The FMS 2, on the First Officer's side.

Each FMS uses:

- A computer, called the Flight Management Computer (FMC)
- The following cockpit interfaces:
  - One Multi-Function Display (MFD)

- One Navigation Display (ND)
- One Primary Flight Display (PFD)
- One electronic flight instrument system Control Panel (EFIS CP)
- One Keyboard and Cursor Control Unit (KCCU).

There are three flight management computers: FMC-A; FMC-B; and FMC-C.

In normal operation:

– FMC-A provides data to FMS 1

– FMC-B provides data to FMS 2

– FMC-C is the standby computer.

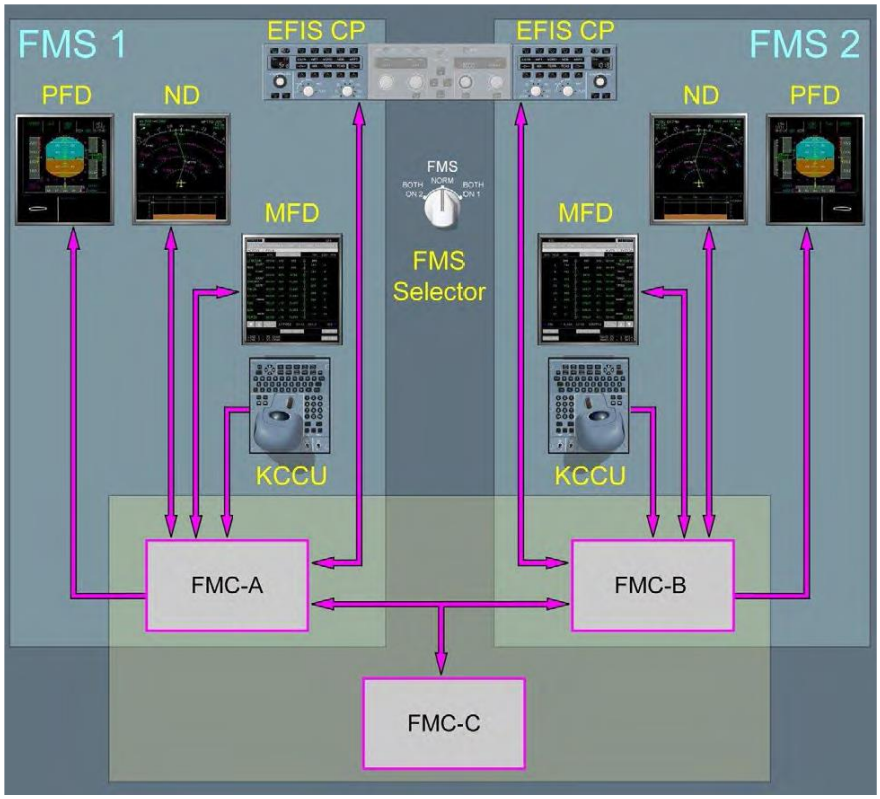


Figure 18. FMS [Source: Airbus]

Of the two active FMCs, one FMC is the “master”, the other is the “slave”. This depends on which Autopilot (AP) is active, and on the selected position of the FMS Source Select sw.

The two active FMCs independently calculate data, and they exchange, compare, and synchronize this data. The standby FMC does not perform any calculation.

The FMCs of the Aircraft were loaded with Navigation database EX61709002. According to the OFP which was inserted into the FMS, the arrival at UUDD was ILS 14R, standard arrival (STAR) AO14K via AMTAM, and standard arrival transition FE1D.

1.6.3 ILS Information on PFD

The ILS information is provided and displayed on the primary flight display (PFD) when the navigation-multimode receiver (MMR[12]), distance measuring equipment (DME), and flight management system (FMS) provide ILS information. The displayed ILS information, as shown in figure 18, are the ILS identification, ILS frequency (in MHz), and aircraft distance to the DME when the ILS has a DME.

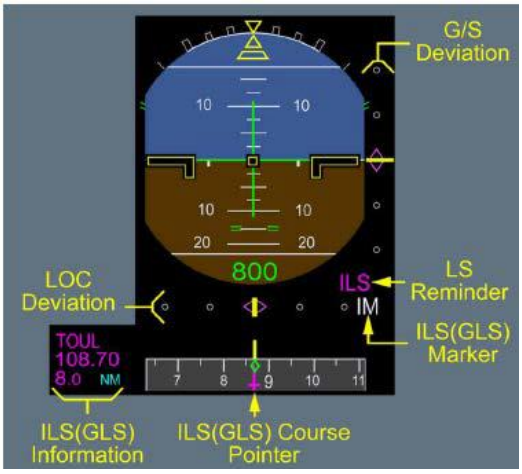


Figure 19. ILS information on PFD [Source: Airbus]

The localizer (LOC) deviation appears when the localizer signal is available, and landing system (LS) pushbutton is pressed (light On, means activated). When LS pushbutton is activated, the landing system data in accordance with the approach selected on the FMS ARRIVAL page (deviation scales, deviation signals, course pointer, and information) will be displayed on the PFD.

The glideslope (G/S) deviation appears when the glideslope signal is available, LS pushbutton is pressed, and flight crew have not selected a back beam course.

1.6.4 Localizer (LOC) modes with the automatic flight system

The localizer capture mode (LOC*) engages, when localizer mode is armed (LOC), and the aircraft reaches the capture zone, or the pre-capture zone of the LOC beam.

The capture zone is a zone available, when the LOC deviation is less than 2.3 dots.

The pre-capture zone is a zone available, when:

- The LOC deviation is more than 2.3 dots
- The FMS is in GPS PRIMARY

When LOC is armed, and the aircraft reaches the pre-capture zone of the LOC beam, LOC* engages, and pre-captures the LOC beam, by using FMS data.

When the LOC deviation becomes less than 2.3 dots, LOC* no longer uses the FMS data: LOC* performs the LOC capture by using the LOC deviation.

Note: On the PFD, and on the ND, the flight crew will observe movement of the LOC deviation toward the center of the scale, only when the LOC deviation is less than 2 dots. This occurs when the aircraft is in the capture zone.

The pre-capture of the LOC beam allows to:

- Enhance the performance of the LOC capture

[12] Each MMR computes LOC and G/S deviations. Each ILS receiver is hosted in one MMR

- Avoid a false capture
- Capture the LOC beam without overshoot.

1.6.5 Navigation display (ND) and vertical display (VD)

The Navigation Display (ND) provides the flight crew with mid-term information on the status of the lateral navigation of the aircraft, according to the flight plan, and data from the navigation database (waypoints, NAVAIDS, airports).

The flight crew can change some items in the flight plan directly from the ND.

The ND also displays:

- The weather radar, the terrain, or information about traffic collision avoidance; and
- The airport navigation function

The Vertical Display (VD) provides the flight crew with an overview of the vertical position of the aircraft. The VD is a secondary means of navigation, that helps increase the flight crew's awareness of the aircraft vertical location.

The VD is only available in ARC and ROSE-NAV modes.

The VD provides the current aircraft position, in relation to the:

- Safety altitudes
- Predicted trajectory
- Weather information
- Terrain information.

The VD is below the Navigation Display (ND).

Figure 20 shows an example of the status of lateral and vertical navigation of an aircraft.

Figure 20. Example of status of lateral and vertical navigation on ND and VD
[Source: Airbus]

1.6.6 Terrain awareness and warning system (TAWS)

The Aircraft was equipped with a surveillance (SURV) system, which includes terrain awareness and warning system (TAWS), weather radar (WXR) system, traffic collision avoidance system (TCAS), and transponder (XPDR).

The TAWS:

- detects terrain collision threats;
- displays terrain information; and
- triggers applicable aural and visual alerts.

The TAWS has:

- a ground proximity warning system (GPWS) function with five basic modes
- a terrain (TERR) function using a terrain database (TAWS database) for terrain display and the predictive mode.

The TERR function provides displays and alerts, based on the comparison between the current aircraft position and the TAWS database.

If the flight crew sets the TERR SYS button of the MFD SURV/CONTROLS page to ON, the TERR function provides:

- A horizontal view of the terrain on the ND, if the flight crew presses the TERR pushbutton on the EFIS CP or if the TAWS triggers an alert the ND displays terrain in different colors, depending on the terrain altitude in relation to the aircraft altitude; and
- A vertical view of the terrain on the VD.

The VD always displays:

- Terrain in brown
- Water in blue.

1.6.6.1 Terrain awareness and display (TAD)

If the terrain awareness and display (TAD) detects a terrain or an obstacle collision threats ahead of the aircraft, the following are triggered:

- A caution, if the aircraft is approximately 60 s away from the conflict terrain.
- A warning, if the aircraft is approximately 30 s away from the conflict terrain.

The TAD function is available in all flight phases, and for all gear and flap configurations.

If the TAD detects a terrain collision threat ahead of the aircraft, the following are triggered:

- The “TERRAIN AHEAD, TERRAIN AHEAD” aural alert that repeats every 7 s, until the terrain is no longer a threat
- The TERRAIN visual alert on the NDs
  The TERR pb is also automatically pressed on the EFIS CP.
- Yellow areas on the NDs, that indicate a terrain conflict with the caution criteria.

If the aircraft continues to approach the terrain, the following are triggered:

- The “TERRAIN AHEAD, PULL UP” aural alert, that repeats continuously, until the terrain is no longer a threat
- The TERRAIN visual alert on the NDs
- Red areas on the NDs, that indicate a terrain conflict with the warning criteria.

1.6.6.2 Descent below glideslope (Mode 5)

According to the *Flight Crew Operating Manual*, if the aircraft descends below the glideslope by more than 1.3 dots during ILS/GLS approaches, the following alerts are triggered:

- The "GLIDESLOPE" aural alert that repeats as long as the aircraft remains below the glideslope.

  If the glideslope slope deviation is more than 2 dots below 300 ft, the aural alert becomes louder, and repeats more and more frequently.

- The GLIDE SLOPE visual alert on the PFD.

Mode 5 is active during approach, if the landing gear is down, and the aircraft is below 1 000 ft and above 30 ft AGL.

The flight crew can deactivate mode 5 by:

- Setting the G/S MODE button to OFF on the SURV CONTROLS page of the MFD, or
- Pressing the G/S MODE pb on the SURV panel.

1.6.7 Maintenance

Based on the last three months maintenance records provided to the Investigation, there was no discrepancies found on the system/equipment related to the functioning of the FMS, MMR, and ILS.

There was no reported significant technical defects prior to the Incident, nor was there any mechanical or automation anomaly prior to the liftoff.

1.7 Meteorological Information

Table 10 shows the METAR [13] for Domodedovo International Airport on 10 September 2017, over the period from 1730 to 1900 UTC.

Table 10. METAR, 10 September 2017, 1730 to 1900 UTC
METAR UUDD 101730Z 18004MPS 9999 FEW040 15/12 Q1015 R88/010095 NOSIG=[14] **METAR UUDD 101800Z 18004MPS CAVOK**[15] **15/11 Q1015 R88/010095 NOSIG** **METAR UUDD 101830Z 18003MPS CAVOK 14/11 Q1015 R88/010095 NOSIG** **METAR UUDD 101900Z 21003MPS 170V230 CAVOK 14/11 Q1015 R88/010095 NOSIG**

Table 11 describes the above mentioned METAR.

Table 11. Description of the METAR		
	1730 UTC	**1800 UTC**
Wind	Direction 180° / speed 4 meters per second	Direction 180° / speed 4 meters per second.
Visibility	10 km or more	10 km or more
Clouds	1/8 to 2/8 of cloud with base at 4,000 feet	No Significant cloud

[13] METAR is a format for reporting weather information (Aviation Routine Weather Report)

[14] NOSIG means that no significant change is expected to the reported conditions within the next 2 hours

[15] CAVOK stands for ceiling and visibility okay, which means that the visibility is 10 kilometers or more and no clouds below 5,000 feet or below the highest Minimum Safe/Sector Altitude (MSA) whichever is the highest.

OAT	15°C	15°C
Dew Point	12°C	11°C
Pressure (Altimeter)	QNH 1015 mbar (hPa)	QNH 1015 mbar (hPa)
Runway	Both runways condition: clear and dry, 10% and less runway contamination with less than 1 mm depth water deposition, and braking action good.	Both runways condition: clear and dry, 10% and less runway contamination with less than 1 mm depth water deposition, and braking action good.
Condition	No significant weather phenomena and nil significant changes	No significant weather phenomena and nil significant changes
1830 UTC		**1900 UTC**
Wind	Direction 180° / speed 3 meters per second	Direction 180° / speed 3 meters per second, with variation of wind direction between 170º and 230º
Visibility	10 km or more	10 km or more
Clouds	No Significant cloud	No Significant cloud
OAT	14°C	14°C
Dew Point	11°C	11°C
Pressure (Altimeter)	QNH 1015 mbar (hPa)	QNH 1015 mbar (hPa)
Runway	Both runways condition: clear and dry, 10% and less runway contamination with less than 1 mm depth water deposition, and braking action good.	Both runways condition: clear and dry, 10% and less runway contamination with less than 1 mm depth water deposition, and braking action good.
Condition	No significant weather phenomena and nil significant changes.	No significant weather phenomena and nil significant changes.

On 10 September 2017, the sunset time at Moscow was 18:58 LT or 15:58 UTC.

1.8 Aids to Navigation

Runway 14R was equipped for ILS CAT IIIA operations. It was provided with distance measuring equipment (DME). The IDM point was the DME which read zero at the threshold of runway 14R (figure A2.3). Precision approach path indicator (PAPI) as visual ground aids was available.

The airport was equipped with non-directional beacons (NDB). For this flight, the Aircraft used the Aksinyino AO NDB for the standard arrival. The AO NDB position was used by reference to GPS coordinates and not as a NDB, since the Aircraft was not equipped with automatic direction finder (ADF).

The Aircraft was equipped with the required navigational equipment, which consisted of air data inertial reference system (ADIRS), global positioning system (GPS), very high frequency omnidirectional range (VOR) receivers, ILS receivers, DME receivers, marker beacon system (included in VOR receiver 1), and flight management system (FMS).

The ground-based navigation aids, visual ground aids were serviceable. The on-board navigation aids were serviceable and were operating normally.

1.9 Communications

Communications between air traffic control and EK131 were recorded by Domodedovo ATC and were made available to the Investigation. All communications between the flight crew and Tower on 118.6 MHz, and Approach on frequency 127.7 MHz were clear.

1.10 Aerodrome Information

Domodedovo International Airport, ICAO code UUDD, coordinates 55º24'31"N 037º54'22"E on the middle between both runways, 14L/32R and 14R/32L, and is located 22.7 nautical miles (42 kilometers) south-southeast of the centre of Moscow, Russia. The airport elevation is 594 feet (181 meters).

The airport was equipped with two concrete runways: 14L/32R with a length of 3,794 meters, and 14R/32L with 3,500 meters length.

Runway 14L/32R is equipped with ILS CAT I[16]/ ILS CAT IIIA[17] precision approach lighting system capability. While, runway 14R/32L is equipped with ILS CAT IIIA/ ILS CAT I precision approach lighting system capability.

However, runway 32R was not suitable for A380 aircraft, as stated in the Operator's crew critical information (CCI) for the flight crew (see Appendix 5).

1.11 Flight Recorders

The Aircraft was equipped with a digital flight data recorder (DFDR) and a cockpit voice recorder (CVR) as indicated in table 12.

Table 12. Flight recorders

	Type	Part Number	Serial Number
CVR	L-3 Comm	2100-1026-02	000564259
DFDR	L-3 Comm	2100-4045-00	000564259

Data from the DFDR and CVR were downloaded and read out, and the Investigation retrieved useful data only from DFDR.

The last two-hours voice data was for the return flight from Moscow to Dubai, Therefore the Investigation could not utilize the CVR data.

Detailed relevant read-out and event descriptions from the DFDR data were examined (Appendix 1). Prior to that, the time between the DFDR and ATC transcript data was synchronized.

1.12 Wreckage and Impact Information

The Aircraft was undamaged.

1.13 Medical and Pathological Information

No medical or pathological investigations were conducted as a result of the Incident.

1.14 Fire

There was no sign of fire.

1.15 Survival Aspects

None of the persons onboard sustained any injury.

[16] A category I approach is a precision instrument approach and landing with a decision height of 200 ft (61 meters) and a runway visual range (RVR) of not less than 1,800 ft (550 meters).

[17] A category III A approach is a precision instrument approach and landing with no decision height or a decision height lower than 100 ft (30 meters) and an RVR of not less than 700 ft (200 meters).

1.16 Tests and Research

Following the first go-around, an FMC-A reset occurred and was recorded on the post flight report (PFR). The FMS BITE[18] was downloaded, and was sent to the Aircraft manufacturer to determine the cause of the FMS reset. The Aircraft manufacturer then provided the FMS BITE data to the FMS manufacturer for a detailed analysis of the FMS reset.

The Aircraft manufacturer provided a detailed analysis, performed by the FMS manufacturer, of the Incident including an analysis of the FMS reset.

1.17 Organizational and Management Information

1.17.1 The Operator

Emirates was established in March 1985, and was granted air operator certificate (AOC) No. AC-0001 issued by the General Civil Aviation Authority of the United Arab Emirates.

The Operator utilized a fleet of Airbus A380 and Boeing B777 aircraft for its commercial transport operations.

1.17.2 Flight crew training

1.17.2.1 Flight training

In accordance with the Operator's *Operations Manual – Part D*, pilots shall complete cross crew qualification (CCQ) training when undergoing a conversion course from one member of a family of aircraft types to another member of the same family. The CCQ training was applicable to the Commander only, since he transferred to the A380 fleet from the A330/A340.

All newly joining pilots may complete the applicable differences and familiarization training in accordance with the Operator's *Operations Manual – Part D*. A pilot is required to complete a type-rating course when changing from one type to another type or class for which a new type or class rating is required. After converting to an aircraft for which a new type or class rating is required, or on first joining the Operator, each pilot must satisfactorily complete the conversion course before commencing unsupervised line flying. The Co-pilot had flown the B737 before joining Emirates, and he underwent the required A380 type-rating course and conversion course when joining, since he went directly to the A380 fleet with Emirates.

ILS operations with different conditions covering different scenarios are included in the Operator's A380 conversion training, recurrent training and checking, and pilot development program, which is designed to assist selected trainees in developing competencies in operating and managing an airline crew in a modern flight deck environment. Glideslope interception from above is included in the conversion training, and recurrent training, including checking.

The Operator normally conducts line continuation training (LCT) in the fourth month following the line release check (LRC) for all transition course trainees. The LRC is conducted prior to a trainee's first recurrent pilot proficiency check (PPC). Not all trainees were required to undergo LCT. The only requirement to conduct LCT was for those trainees whom it was believed by the instructor required it. There was no evidence that the flight crew underwent LCT.

[18] Built-in test equipment (BITE) is a function of the FMS, which provides continuous monitoring of the related computers, control display units, sensors, and components that interface with the FMS.

1.17.2.2 Crew resource management training

Crew resource management (CRM) training is provided to all pilots in accordance with the *OM-D*.

Initial CRM is provided to all pilots joining the Operator with the objective of delivering the Operator's perspective on CRM.

Type conversion CRM is provided for pilots who change to a different type of aircraft. For pilots joining the Operator, this course is delivered as part of the footprint of the training provided for new joiners. For existing pilots, it is provided as per footprints relevant to fleet transfers. The focus of this course was on the application of the Operator' operations policy concerning the use of automation as well as on the system and human limitations of automation.

Command CRM was a two-day course provided by the Operator as part of the nomination to commander. The course was structured as required by the *Civil Aviation Regulations*, but also went beyond by providing additional focus on leadership as well as on the role of personality in managing oneself and others.

Recurrent CRM is delivered annually. All elements of the CRM initial course are covered over a period of three years.

1.17.3 Descent

The *Operations Manual - Part A (OM-A) states that* for descent, where the FMS or a procedural vertical profile require greater rates, the reasons and conditions shall be briefed by the flight crew. The values shown in table 13 for the rate of descent shall not be exceeded, except for momentary excursions of a few seconds where indications are that the rate will return within limits.

Table 13. Rate of descent limitation

Altitude above Terrain (feet)	**Rate of Descent** (feet per minute)
Descent to 5,000	5,000
5,000 to 3,000	3,000
3,000 to 1,000	2,000
1,000 to landing	1,000

1.17.4 Verbal risk based briefing

Each operating pilot shall review the relevant details for arrival and approach and shall accomplish a 'self-brief' during the FMC/FMS setup, data entry and crosschecking phase, prior to a verbal briefing. As per the *OM-A*, the verbal risk-based briefing shall be accomplished prior to commencement of each approach, using the standard format: chart; terrain; weather; operational; and fuel.

1.17.5 Usage of checklist and callouts, actuation of critical controls

As per the *OM-A*, the checklists shall be used before, during and after all phases of flight and in abnormal and emergency situations in accordance with the *flight crew operating manual (FCOM)*. The appropriate checklist shall be read aloud and responded to in accordance with standard operating procedures (SOP). A checklist shall never be recited from memory unless specified by the *FCOM*. All standard calls are to be made and acknowledged in accordance with the *SOP*.

Whenever a flight crewmember makes an adjustment or change to any setting or control, he shall advise the other crewmember of his action and intention, and receive an acknowledgement from the other crewmember. Examples of such control adjustments include: FMC/FMS changes; mode control panel (MCP)/FCU changes; flight plan deviation; ATC instructions; and system switching or selection.

1.17.6 Standard operating procedures (SOP) for approach

The SOPs for approach were provided in the *FCOM*, and in the *flight crew techniques manual (FCTM)*.

1.17.6.1 Approach SOP in the *FCOM*

The *FCOM* described the SOP for an ILS approach as: flying reference, stabilization criteria, and approach speed technique.

ILS approach refers to an approach (APPR) using localizer (LOC) and glideslope (G/S).

"Flying Reference

The following flying reference are recommended:

- HDG-V/S in vertical managed modes
- TRK-FPA in vertical selected modes

Stabilization criteria

The stabilization height is defined as one of the following:

- 1,000 ft above airfield elevation in Instrument Meteorological Conditions (IMC), or
- 500 ft above airfield elevation in Visual Meteorological Conditions (VMC), or
- Any other height defined in Operator policies or regulations.

In order for the approach to be stabilized, all of the following conditions must be satisfied before, or at the stabilization height:

- The aircraft is on the correct lateral and vertical flight plan
- The aircraft is in the desired landing configuration
- Thrust is stabilized, usually above idle, and the aircraft is at target speed for approach

Note. In IMC, if the ATC requests a speed constraint that is not compatible with the speed and thrust stabilization at 1 000 ft above aerodrome level (AAL), a later speed and thrust stabilization can be acceptable provided that:

- *The aircraft is in deceleration toward the target approach speed*
- *The flight crew stabilizes speed and thrust as soon as possible and not later than 500 ft AAL.*
- The flight crew does not detect any excessive flight parameter deviation.

If one of the above-mentioned conditions is not satisfied, the flight crew must initiate a go-around, unless they estimate that only small corrections are required to recover stabilized approach conditions."

Note: As per the *Operations Manual-Part A (OM-A)*, there is no difference between IMC and VMC for the stabilization criteria. The *OM-A* has precedence over the *FCOM* as per Operator's policy. Therefore, the only stabilization gate established by the Operator is 1,000 feet AAL.

"Approach speed technique

Decelerated Approach

The decelerated approach with FD or AP/FD guidance is the standard flying reference technique for ILS approach.

Early Stabilized Approach

The flight crew may decide to reduce the speed down to VAPP in the landing configuration at the final descent point.

For this purpose, the flight crew may enter VAPP as a speed constraint at the final descent point."

The SOP for an ILS approach according to the manufacturer's *FCOM* prescribes the following aspects: flying reference, stabilization criteria, approach speed technique, and discontinued approach. The first three aspects were similar to the Operator's *FCOM*.

The SOP for the discontinued ILS approach aspect according to the Manufacturer's *FCOM* is as follows:

"**Discontinued Approach**

In order to discontinue an approach when the aircraft is at or above the altitude selected on the FCU, the flight crew can either:

- Apply the GO AROUND procedure, or
- Apply the discontinued approach technique, as described below.

When the aircraft is below the FCU altitude, the flight crew must apply the GO AROUND procedure.

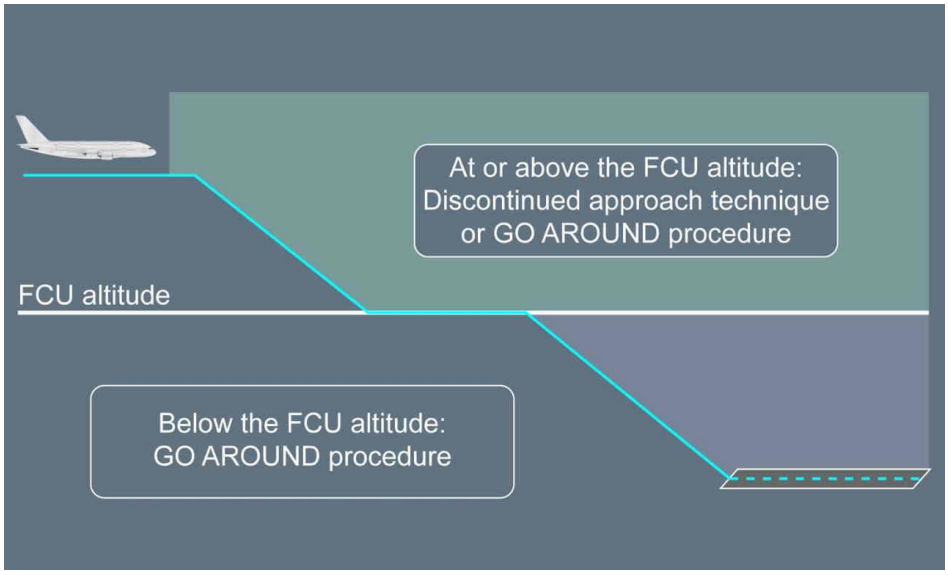


Figure 21 – Discontinued approach [Source: Airbus]

- **If at or above the FCU altitude:**

  Announce "CANCEL APPROACH".

  To disengage and disarm any approach mode, press APPR pb or LOC pb.

  Select lateral mode as required (NAV or HDG mode).

  Select vertical mode as required.

  Select SPEED and adjust.

- **If F-PLN has no destination anymore:**

Perform a lateral revision at the last waypoint and redefine the destination in the NEW DEST field.

Note 1. The FMS does not automatically string the previous flown approach in the active F-PLN.

When the last waypoint is sequenced, the FMS has no more destination in the F-PLN

2. Because the thrust levers are not set to TOGA detent, the FMS remains in approach phase."

The SOP for a discontinued approach was not included in the Operator's *FCOM*.

Aircraft configuration management

The SOP for the aircraft configuration management for an ILS approach, according to the *FCOM,* covers the approach phases: initial approach, and intermediate/final approach. The related SOPs are provided in appendix 3.1 to this Report.

Aircraft guidance management

The SOP for the aircraft guidance management for an ILS approach, means using localizer (LOC) and glideslope (G/S) guidance according to the *FCOM*, covers the approach phases: initial/intermediate approach, glideslope intercept from above, final approach, at minimum +100 feet, and at minimum. The related SOPs are provided in appendix 3.2 to this Report.

1.17.6.2 Approach standard operating procedures contained in the *FCTM*

The *FCTM* provides complementary information to the *FCOM*. The *FCTM* provides the flight crew with:

- The general Airbus operational philosophy (e.g. design and utilization principles, golden rules for pilots)
- Additional information to the *FCOM* procedures (the "why" to do and the "how" to do)
- Best practices, operating techniques on maneuvers, and handling
- Information on situational awareness.

If the *FCTM* data differs from the *FCOM* data, the *FCOM* remains the reference.

The SOP for the approach, according to the *FCTM,* was divided into initial, intermediate, and final approach, where the flight crew should perform associated configuration management and guidance management (figure 22).

- On initial approach, the flight crew is required to:
  - Check navigation accuracy;
  - Select approach type and strategy
- On intermediate approach, the flight crew is required to:
  - Manage aircraft deceleration according to the strategy (early stabilized or decelerated);
  - Manage the final approach path interception;
  - Select flying reference
- On the final approach, the flight crew is required to :
  - Monitor correct engagement of the intended approach modes;

- Monitor the trajectory according to the approach strategy;
- Be stabilized at 1,000 ft (500 ft)

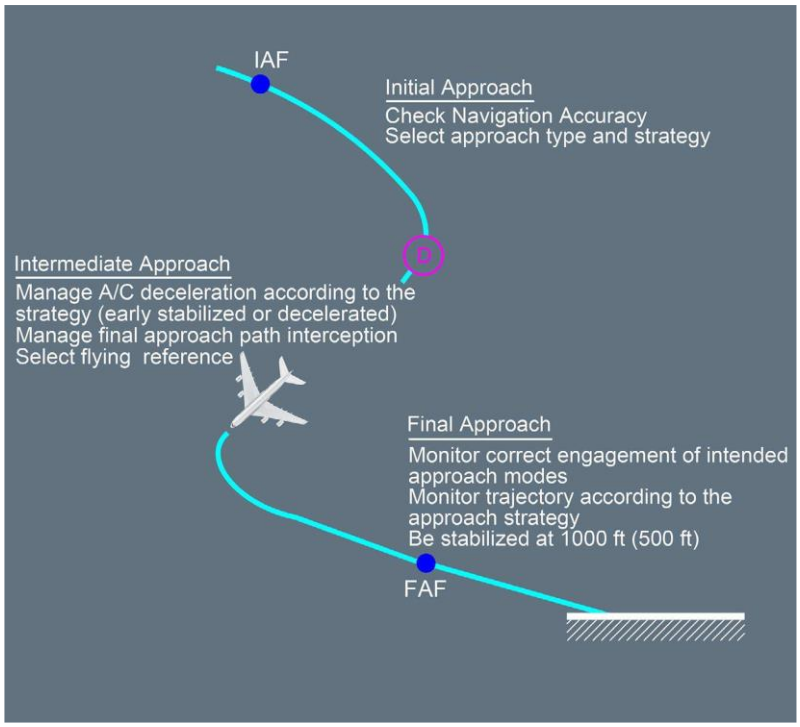


Figure 22. Approach SOP according to the *FCTM* [Source: Airbus]

The approach speed strategy for the intermediate approach consists of two techniques: decelerated approach; and early stabilized approach.

DECELERATED APPROACH

This technique refers to an approach where the aircraft reaches 1 000 ft AGL in the landing configuration, at VAPP. In most cases, this means that the aircraft is in FLAP 1 and at S speed at the FAF.
This is the preferred technique for ILS approaches or for NPA flown with the FLS function, in the F-APP or F-APP+RAW cases. The deceleration pseudo waypoint D computed by the FMS assumes a decelerated approach technique.

EARLY STABILIZED APPROACH

This technique refers to an approach where the aircraft reaches the FAF in the landing configuration at VAPP. This technique is recommended for non-precision approach flown without the FLS function.
To get a valuable deceleration pseudo waypoint and to ensure a timely deceleration, the flight crew should enter VAPP as a speed constraint at the FAF.

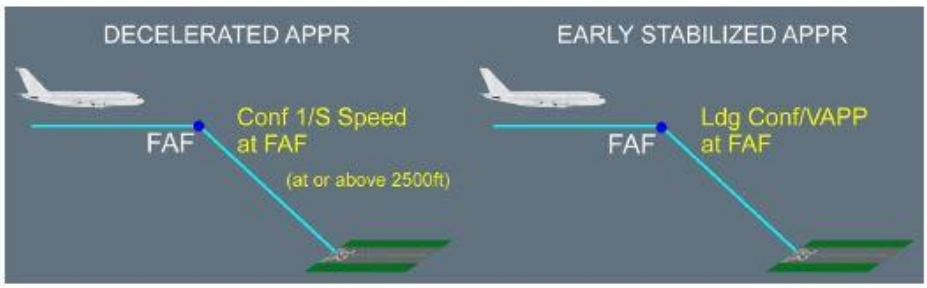


Figure 23. Approach speed strategy [Source: Airbus]

”

The SOP for a discontinued approach was not included in the Operator’s *FCTM*. However, this SOP was included in the manufacturer’s Airbus A380 *FCTM*, as follows:

> “**Discontinued Approach**
>
> The discontinued approach is an alternative technique to the GO AROUND procedure to interrupt an approach when the aircraft is at or above the selected FCU altitude.
>
> Contrary to the GO AROUND procedure, the discontinued approach technique does not require the flight crew to set the thrust levers to TOGA detent.
>
> The flight crew should initiate the discontinued approach technique with the callout: “CANCEL APPROACH”
>
> The first action of the flight crew is to engage and disarm any AP/FD approach mode, by pressing the APPR pushbutton or LOC pushbutton.”

Aircraft configuration management

The SOP for the aircraft configuration management for a general approach according to the *FCTM* covers the approach phases: initial approach, intermediate, and final approach.

The related SOPs are provided in Appendix 3.3 to this Report.

Aircraft guidance management

The SOP for the aircraft guidance management for a general, and specifically for an ILS approach using localizer (LOC) and glideslope (G/S) guidance according to the *FCTM* covers the approach phases: initial, intermediate, and final approach.

The related SOPs are provided in appendix 3.4 to this Report.

ILS approach specificities

The SOP for the specificities for an ILS approach, according to the *FCOM,* cover CAT I ILS, and CAT II or CAT III ILS. Recommendations mentioned for a general approach, as mentioned in appendix 3.4, apply.

For a CAT I ILS, the flight crew should insert a DA value in the BARO entry field of the APPR panel of the FMS ACTIVE/PERF page because that value is barometrically referenced.

For a CAT II or CAT III ILS, the flight crew should insert DH value in the RADIO entry field of the APPR panel of the FMS ACTIVE/PERF page because that value is radio altitude referenced.

The related SOPs are provided in appendix 3.5 to this Report.

Glide interception from above

The standard operating procedures (SOP) for the glideslope interception of an ILS from above according to the *FCTM* are provided in appendix 3.6 to this Report.

1.17.7 Go-around SOP

1.17.7.1 Go-around SOP in the *FCOM*

The SOP for a go-around, according to the *FCOM,* prescribes the following aspects: go-around initiation, and at go-around acceleration altitude.

The related SOPs are provided in appendix 3.7 to this Report.

1.17.7.2 Go-around SOP in the *FCTM*

The SOP for go-around, according to the *FCTM,* prescribed the following aspects: consideration of the go-around, AP/FD go-around phase activation, go-around phase, and leaving the go-around phase.

The related SOPs are provided in appendix 3.8 to this Report.

1.17.8 ILS glideslope coverage

As provided in the *FCOM* and *FCTM*, ICAO defines the envelope in which the quality of the glideslope (G/S) signal ensures a normal capture (figure 24). This envelope is within 10 NM, ± 8 ° from the centerline of the ILS glideslope path, and up to 1.75 theta (theta (θ), being the nominal glideslope path angle). If the approach is armed when the aircraft is far outside of the standard G/S capture envelope, a spurious G/S* engagement may occur, due to an incorrect G/S deviation signal. Each time that the flight crew notices pitch movement, or a spurious G/S*, or a trajectory deviation, they must immediately disconnect the AP, if engaged, in order to re-establish a normal attitude and disengage APPR mode. It is then recommended to arm/rearm the APP (ILS) mode within the normal capture zone.

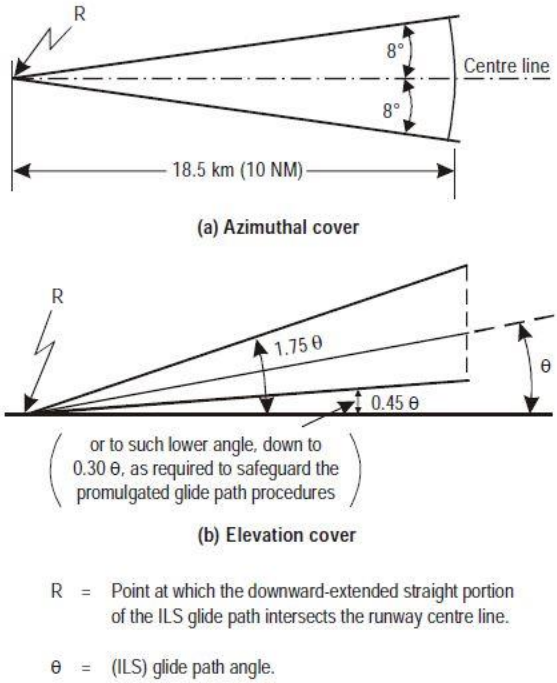


Figure 24. Envelope of ILS glideslope signal quality [Source: ICAO Annex 10]

1.17.9 *OM–A* for flight recorder preservation

The *OM-A* contained the following procedures:

> "**2.1.3.2.3 Preservation, Production and Use of Flight Recorder Recordings**
>
> All flight data and derived information is sensitive. Access to such data and information shall be controlled and monitored and the security, integrity and confidentiality of all flight data and derived information shall be protected with all reasonable safeguards.
>
> Following an accident or serious incident, Emirates preserves the original recorded data per CAR requirements or as directed by the investigating

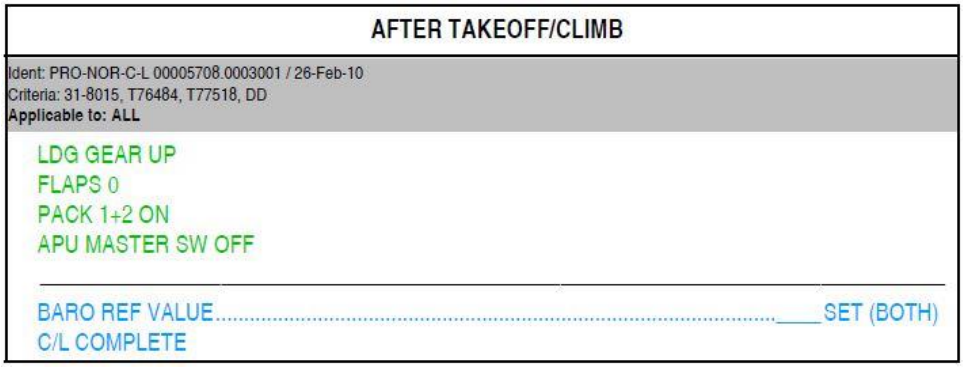
authority. In addition, if requested to do so by the UAE GCAA, any recording must be made available to them within reasonable time."

1.17.10 Operator's normal checklists

According to the *FCOM*, the following normal checklists illustrate:

- Detected items already completed
- Non-detected items, before they are manually selected with the tick pb on the ECAM control panel.

The *after takeoff/climb* checklist was described in figure 25.



AFTER TAKEOFF/CLIMB

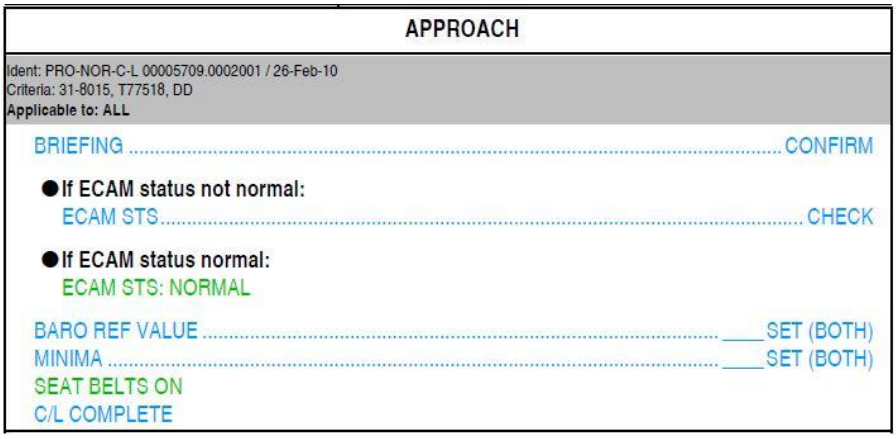
Ident: PRO-NOR-C-L 00005708.0003001 / 26-Feb-10
Criteria: 31-8015, T76484, T77518, DD
Applicable to: ALL

LDG GEAR UP
FLAPS 0
PACK 1+2 ON
APU MASTER SW OFF

BARO REF VALUE.....____SET (BOTH)
C/L COMPLETE

Figure 25. After Takeoff/Climb checklist

The *approach* normal checklist was described in figure 26.



APPROACH

Ident: PRO-NOR-C-L 00005709.0002001 / 26-Feb-10
Criteria: 31-8015, T77518, DD
Applicable to: ALL

BRIEFING ..... CONFIRM

● **If ECAM status not normal:**
ECAM STS..... CHECK

● **If ECAM status normal:**
ECAM STS: NORMAL

BARO REF VALUE ..... ____SET (BOTH)
MINIMA ..... ____SET (BOTH)
SEAT BELTS ON
C/L COMPLETE

Figure 26. Approach checklist

The *landing* normal checklist was described in figure 27.

LANDING

Ident: PRO-NOR-C-L 00005710.0007001 / 03-Dec-14
Criteria: 31-8015, 42-8020, 42-8028, T76484, T77518, T78651, T83176, T83753, DD
Applicable to: ALL

CABIN CREW ..... ADVISE
A/THR ..... AS RQRD

● **If AUTO BRAKE function is available:**
AUTO BRK ..... AS RQRD

LDG

SIGNS ON
LDG GEAR DOWN
FLAPS LDG

The FLAPS LDG appears completed (i.e. in green), when the flaps lever position is in accordance with the landing configuration, entered on the APPR panel of the FMS ACTIVE PERF page.

SPLRs : ARM
C/L COMPLETE

Figure 27. Landing checklist

1.17.11 Standard callouts

The approach and landing standard callouts were described in the manufacturer's *FCOM* as shown in figure 28.

Approach and Landing		
Event	**PF**	**PM**
Approach checklist	APPROACH C/L	APPROACH C/L COMPLETE
Activation of approach phase	ACTIVATE APPROACH PHASE	APPROACH PHASE ACTIVATED
RA alive	CHECKED	RADIO ALTIMETER ALIVE(1)(2)
At G/S* or below GO altitude for NPA, without AP	SET GA ALTITUDE_FT	GA ALTITUDE__SET
FAF	CHECKED	PASSING__(Fix Name)__FT
Landing checklist	LANDING C/L	LANDING C/L COMPLETE
1 000 ft RA	CHECKED	ONE THOUSAND(2)
100 ft above MDA/DH	CHECKED	ONE HUNDRED ABOVE(2)
Visual references at MDA/DH	CONTINUE	MINIMUM(2)
No visual reference at MDA/DH	GO-AROUND - FLAPS	MINIMUM(2)
100 ft RA 50 ft RA		ONE HUNDRED(2) FIFTY(2)
After touchdown Ground spoilers extended REV on EWD		SPOILERS(3) REVERSE GREEN(4)

Approach and Landing		
Event	**PF**	**PM**
Deceleration		DECEL(5)
At 70 kt	CHECKED	SEVENTY KNOTS

Figure 28. Approach and landing standard callouts

The go-around standard callouts as described in the Operator's *FCOM* as shown in figure 29.

Go-Around		
Event	**PF**	**PM**
GO-AROUND decision	GO-AROUND – FLAPS	
Flaps retraction		FLAPS__
Gear retraction	GEAR UP	POSITIVE CLIMB GEAR UP
Checklist	AFTER TAKEOFF/CLIMB C/L	DOWN TO THE LINE
At transition altitude	BELOW THE LINE	AFTER TAKEOFF/CLIMB C/L COMPLETE

Figure 29. Go-around standard callouts

1.18 Additional Information

1.18.1 UAE National Standards of Flight Recorder Preservation

The UAE Civil Aviation Regulations (CAR) part IV – *Operations Regulations*, CAR-OPS 1 – *Commercial & Private Air Transportation (Aeroplanes)* prescribes the requirements for the operations of aeroplanes as commercial and private air transportation.

The requirements for preserving flight recorders as given in the UAE CAR-OPS 1 are as follows:

1. CAR-OPS 1.160 (f)(10)(ii);

"**CAR-OPS-1 1.085 Crew Responsibilities**

(f) The commander shall:

…

(10) Not permit:

…

(ii) A cockpit voice recorder to be disabled or switched off during flight unless he believes that the recorded data, which otherwise would be erased automatically, should be preserved for incident or accident investigation nor permit recorded data to be manually erased during or after flight in the event of an accident or an incident subject to mandatory reporting."

2. CAR-OPS 1.160 (a) (2)

"**CAR-OPS 1.160 Preservation, production and use of flight recorder recordings**

(a) Preservation of recordings

…

(2) Unless prior permission has been granted by the Authority, following an incident that is subject to mandatory reporting, the operator of an aeroplane on which a flight recorder is carried shall, to the extent possible, preserve the original recorded data pertaining to that incident, as retained by the recorder for a period of 60 days unless otherwise directed by the investigating authority."

1.18.2 Required time of speed managed mode and speed selected mode

The Investigation calculated the difference between the 'speed managed' and 'speed selected' modes at 170 knots, as flown. The time calculation is based on the actual groundspeed in order to obtain proper timing for both modes.

1.18.2.1 Required time when using 'speed managed' mode

Assumptions are required to calculate the required time for the Aircraft to reach the extended runway centerline (inbound course for ILS 14R) if 'speed managed' mode is used. The assumption is made that the *glide interception from above* procedure is not applied, and if the Aircraft levels off at 2,300 feet QNH.

When the 'speed managed' mode was set, at 1752:24, the Aircraft was approximately abeam of the AMTAM waypoint, 3.6 nautical miles from the extended runway centerline (inbound course for ILS 14R), while descending passing 2,712 feet pressure altitude.

Equations of second order polynomial related to the airspeed and groundspeed are determined from the time when the 'speed managed' mode was set (1752:24) until the 'speed selected' mode of 170 knots is set (1752:33).

Figure 30 shows the equation for the indicated airspeed for the stated period as:

$y = - 0.062 x^2 + 0.0664 x + 167.51$ …….. (Equation 1)

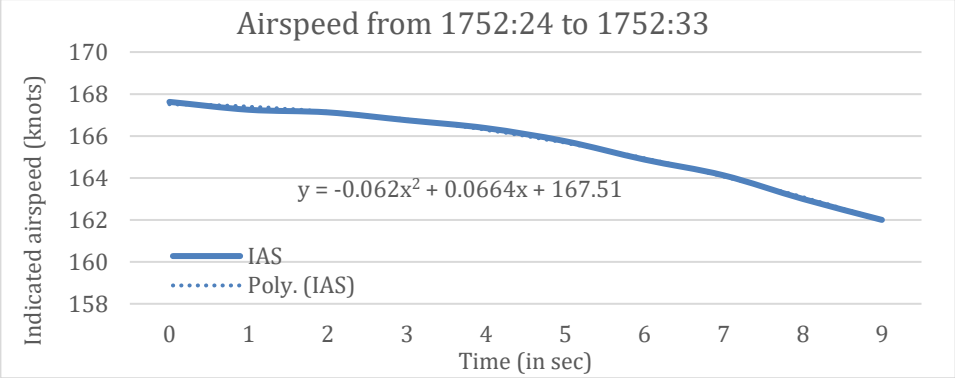


Figure 30. Second order polynomial of IAS

Figure 31 shows the equation for the vertical speed for the stated period as:

$y = 7.5758 x^2 - 16.521 x - 1210.4$ ……(Equation 2)

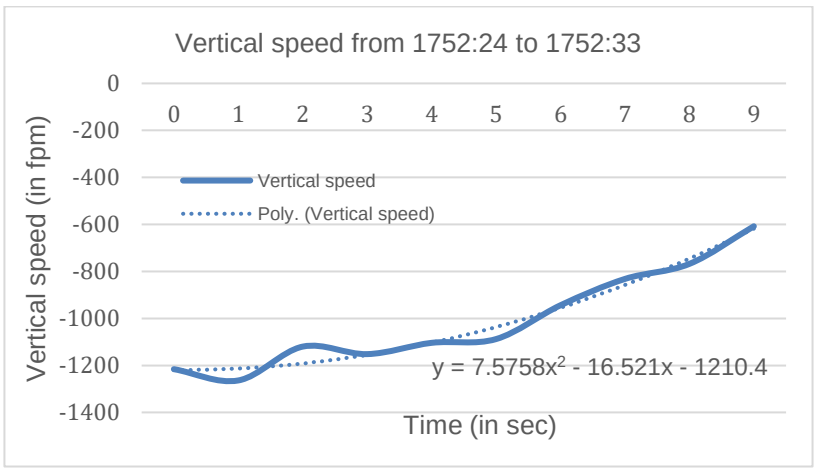


Figure 31. Second order polynomial of V/S

The target speed of the 'speed managed' mode was 143 knots, and by using Equation 1, it takes about 21 seconds for the IAS to reach 143 knots as target speed.

The average of the difference between the indicated airspeed and the groundspeed, from 1752:24 to 1752:33, is 14.2 knots, which is used as the assumption that the wind (speed and direction) is constant after 1752:33. The distance travelled in 21 seconds (from the time of the selection of the 'speed managed' mode until the target speed of 143 knots is reached) is 0.82 nautical miles.

Using equation 2, and given the assumption that the vertical speed is constant after 1752:33, the height reduction of 412 feet requires 29 seconds.

The groundspeed is approximately 129 knots for an indicated airspeed of 143 knots. Therefore, the required time for a distance of 2.78 (≈ 3.6 – 0.82) nautical miles with a groundspeed of 129 knots, is approximately 78 seconds.

Therefore, the Aircraft is expected to reach the inbound course of the runway 14R ILS in 99 (≈ 21 + 78) seconds after the 'speed managed' mode has been set.

1.18.2.2 Required time when using 'speed selected' mode of 170 knots

Assumptions are required to calculate the required time by the Aircraft to reach the runway centerline axis if 'speed selected' mode of 170 knots is used.

The assumption is made that the *glide interception from above* procedure is not applied, and the Aircraft levels off at 2,300 feet QNH.

The calculation is based on the actual groundspeed.

When the speed was selected to 170 knots, at 1752:33, the airspeed was decaying passing 162 knots, and the Aircraft was at about 3.2 nautical miles from the inbound course of ILS 14R, while descending through 2,560 feet pressure altitude.

The Aircraft would have reached 2,300 feet QNH at 1752:50, which means it requires 17 seconds from when the speed was selected to 170 knots. The travelled distance is 0.7 nautical miles. Therefore, the Aircraft is expected at about 2.5 nautical miles from the inbound course of ILS 14R. The airspeed was at 162 knots.

The airspeed reached 170 knots at 1753:02, which means it requires 12 seconds from when the Aircraft reached 2,300 feet QNH and maintained level. The travelled distance for this period of 12 seconds is about 0.5 nautical miles. Therefore, the Aircraft is expected at about 2.0 (≈ 3.2 - 0.7 - 0.5) nautical miles from the inbound course of ILS 14R.

The groundspeed was about 151 knots for 170 knots IAS. Therefore, the required time for a distance of 2.0 nautical miles with a groundspeed of 151 knots, is approximately 48 seconds.

Therefore, the Aircraft is expected to reach the inbound course of the runway 14R ILS in 77 (≈ 17 + 12 + 48) seconds after the "speed selected" mode of 170 knots is set.

1.18.3 Flight path monitoring

Monitoring tasks, including flight path monitoring, is subject to many challenges or barriers related to human factors limitations and has recently been the focus of several industry working groups and related research. The findings from these working groups and studies highlight the various human performance limitations that are detrimental to effective monitoring.

Dismukes and Berman (2010) showed that although checklists and flight crew monitoring are important defences, and in the vast majority of cases are performed appropriately, they do not always catch flight crew errors and equipment malfunctions. They

also noted:

> *"even though automation has enhanced situation awareness in some ways, such as navigation displays, it has undercut situation awareness by moving pilots from direct, continuous control of the aircraft to managing and monitoring systems, a role for which pilots are poorly suited. Also, the very reliability of automation makes it difficult for pilots to force themselves to stay in the loop. Research is needed to develop ways to help pilots stay in the loop on system status, aircraft configuration, flight path, and energy state. These new designs must be intuitive and elicit attention as needed, but minimize effortful processing that competes with the many other attentional demands of managing the flight."*

The United States Flight Safety Foundation (FSF) Active Pilot Monitoring Working Group has developed a practical guide to improve flight path monitoring (Flight Safety Foundation, 2014). The guide listed four general human factors limitations that adversely affect monitoring:

- The human brain has difficulty with sustained vigilance
- The human brain has quite limited ability to multitask
- Humans are vulnerable to interruptions and distractions
- Humans are vulnerable to cognitive limitations that affect what they notice and do not notice.

A number of other factors were identified that could inhibit effective flight path monitoring. These included time pressure, lack of feedback to pilots when their monitoring lapses, the design of flight deck systems and procedures, inadequate mental models of auto-flight system modes and a lack of organizational emphasis and practical guidance on monitoring.

The Dismukes and Berman study examined monitoring deviations and found those relating to *"not monitoring aircraft state or position*" were the least frequent, at 17 per cent. The most common type was a late or omitted call (such as *"1,000 [feet] to go*"), followed by omitted verification of system status. Of interest to this occurrence, the authors found that *"some deviations are clearly unintentional, such as deviations from flight path"*. The authors went on to state that *"given the large numbers of opportunities for deviation, the deviation rates were probably well below one percent"* and *"the vast majority of deviations had no observable outcome".*

The United Kingdom Civil Aviation Authority (CAA) formed a Loss of Control Action Group to examine and provide guidance on, among other things, the development of Pilot Monitoring skills. The resulting guidance emphasized the importance of 'a structured and interactive briefing which *"provides the crew with an opportunity to: share a common action plan; and set priorities and share tasks"* including the need to *"brief the plan for energy management with altitudes and minimum approach gates".*

The FSF working group, the CAA action group and the study by Dismukes and Berman each made a number of recommendations and suggestions in the areas of monitoring practices, policy and procedures, auto-flight system monitoring and training and evaluating monitoring skills. Pilots and operators may benefit from a review of this advice.

1.18.4 Other historical events

Identical issues of the latent factors that occurred in this Incident were also identified in some previous events as presented below.

1.18.4.1 Descent below segment minimum safe altitudes involving Airbus A320-232, Registration VH-VQA

On 16 July 2012 at about 0830 New Zealand Standard Time, an Airbus A320-232 aircraft, registered VH-VQA and operated by Jetstar Airways, was conducting an Area Navigation (Required Navigation Performance) approach to runway 05 at Queenstown, New Zealand. During the approach, the aircraft descended below two segment minimum safe altitudes. Upon recognising the descent profile error, the crew climbed the aircraft to intercept the correct profile and continued the approach to land.

The investigation found that, contrary to their intentions, the crew continued descent with the auto-flight system in open descent mode, which did not provide protection against infringing the instrument approach procedure's segment minimum safe altitudes. The investigation also found that the crew were not strictly adhering to the operator's sterile flight deck procedures, which probably allowed the crew to become distracted.

The investigation found that the operator's procedures did not specifically draw the crew's attention to unchanged auto-flight system modes during descent or prompt crew reconsideration of the most suitable descent mode at any point during descent. Additionally, the operator's procedures allowed the crew to select the altitude to which they were cleared by air traffic control on the Flight Control Unit altitude selector, irrespective of intervening altitude constraints. This combination of procedures provided limited protection against descent through segment minimum safe altitudes.

1.18.4.2 Flight path management and ground proximity warning involving Airbus A330-202, Registration VH-EBV

On 8 March 2013, the flight crew of a Qantas A330 aircraft, registered VH-EBV, was conducting a visual approach to Melbourne Airport, Victoria. The captain was the pilot flying with autopilot engaged.

Soon after being cleared for the approach, on descent through 3,000 ft, the captain set an altitude target of 1,000 ft in the auto-flight system and selected the landing gear down, the first stage of wing flap and 180 kt as the target speed. The descent was continued in auto-flight open descent mode and reached a maximum of 2,200 ft/min. As the aircraft was descending through about 1,800 ft the first officer advised the captain that they were low. The captain reduced the rate of descent by selecting auto-flight vertical speed mode but a short time later the enhanced ground proximity warning system (EGPWS) provided 'TERRAIN' alerts followed by 'PULL UP' warnings. The crew carried out an EGPWS recovery manoeuvre and subsequently landed via an instrument approach.

At the time of the EGPWS alert the aircraft had descended to 1,400 ft, which in that area was 600 ft above ground level, with 9 NM (17 km) to run to touchdown. This was 100 ft below the control area lower limit and 1,900 ft below a normal 3° descent profile.

The investigation found that during the visual approach the captain's performance capability was probably reduced due to the combined effects of disrupted and restricted sleep, a limited recent food intake and a cold/virus. The captain assessed the aircraft's flight path using glide slope indications that were not valid. This resulted in an incorrect assessment that the aircraft was above the nominal descent profile.

In addition, the combination of the selection of an ineffective altitude target while using the auto-flight open descent mode and ineffective monitoring of the aircraft's flight path resulted in a significant deviation below the nominal descent profile. The flight crew's action in reducing the aircraft's rate of descent following their comprehension of the altitude deviation did not prevent the aircraft descending outside controlled airspace and the activation of the EGPWS.

1.18.4.3 Collision with Terrain, involving Airbus A320-211, Registration C-FTJP

On 29 March 2015, an Air Canada Airbus Industrie A320-211 (registration C-FTJP, serial number 233), operating as Air Canada flight 624, was on a scheduled flight from Toronto/Lester B. Pearson International Airport, Ontario, to Halifax/Stanfield International Airport, Nova Scotia, with 133 passengers and 5 crew members on board. At approximately 0030 Atlantic Daylight Time, while conducting a non-precision approach to Runway 05, the aircraft severed power lines, then struck the snow-covered ground about 740 feet before the runway threshold. The aircraft continued airborne through the localizer antenna array, then struck the ground twice more before sliding along the runway. It came to rest on the left side of the runway, about 1900 feet beyond the threshold. The aircraft was evacuated; 25 people sustained injuries and were taken to local hospitals. The aircraft was destroyed. There was no post-impact fire. The accident occurred during the hours of darkness.

As per standard operating procedure (SOP) and practice when flying in flight path angle guidance mode was that, once the aircraft was past the final approach fix, the flight crews were not required to monitor the aircraft's altitude and distance from the threshold or to make any adjustments to the flight path angle. The flight crew followed the SOP and practice. However, the investigation found that this practice was not in accordance with the flight crew operating manuals of Air Canada or Airbus.

The investigation found that the flight crew did not notice that the aircraft had drifted below and diverged from the planned vertical descent angle flight profile, nor were they aware that the aircraft had crossed the minimum descent altitude further back from the threshold.

1.19 Useful or Effective Investigation Techniques

This Investigation was conducted in accordance with Part VI, Chapter 3 of the *Civil Aviation Regulations*, and the AAIS approved policies and procedures, and in conformity with the Standards and Recommended Practices of *Annex 13 to the Chicago Convention*.

2. Analysis

2.1 General

The Investigation collected data from various sources for the purpose of determining the causes and contributing factors that led to the Serious Incident.

This Analysis covers the aspects of the go-around, the discontinued approach, the FMS auto reset, the ILS glide signal, flight crew coordination, the approach techniques used, human factors, and the related Operator's procedures. For detailed descriptions of the flight, see also Appendix 1 to this Report.

This section of the Report explains the contribution of each investigation aspect to the occurrence of the Incident.

The Analysis also contains safety issues that may not have been contributory to the Incident, but are significant in that they adversely affect safety.

2.2 First Approach and Go-around

2.2.1 Arrival

The flight crew stated that they conducted the approach briefing 20 minutes before reaching the top of descent, approximately 115 nautical miles before the Aksinyino (AO) NDB.

In the approach briefing, the flight crew followed the Operator's standard model of arrival charts, terrain, weather, operational requirements, aircraft performance, fuel, and load. The Co-pilot briefed the Commander on the standard arrival procedures as listed in the operational flight plan.

The planned arrival route was FE1D as shown in the STAR transitions chart (figure A2.1), and then a standard arrival through the AO14K, ABMAS and AMTAM waypoints, as shown in the STARs RWYs 14L/R chart (figure A2.2), and finally the ILS approach to runway 14R as shown in the IAC ILS 14R chart (figure A2.3). The Co-pilot briefed that ATC might not provide them with vectors to intercept the localizer when the Aircraft would be at 90-degrees to the final approach track on the base leg, and in this case, the final turn should be determined by the flight crew.

During the descent, the Radar Controller provided vectoring, which resulted in a wider compared to the standard arrival through the AO14K route due to traffic in the vicinity of UUDD (see figure 3). The Aircraft started to slow before the AO NDB waypoint. The selected airspeed was reduced gradually from 315 to 180 knots, as instructed by ATC.

When the Aircraft was vectored onto the arrival and approach segments the Radar Controller was busy managing other traffic and communications. ATC were communicating in Russian with Russian aircraft, and this might have prevented the flight crew from establishing an accurate mental model regarding the ATC instructions being provided to other aircraft in the vicinity that may have resulted in reducing their situational awareness. Except for communications between ATC and EK131, the Co-pilot remembered that ATC had only communicated with one other aircraft using the English language.

According to the FMS BITE data, the approach phase was activated in the FMS by selecting and confirming the 'ACTIVATE APPR' (in amber) displayed on the MFD 'performance' (PERF) page. At this time, the Aircraft was descending through 8,236 feet, and the airspeed was decreasing through 187 knots.

The Radar Controller provided clearance for the ILS approach to runway 14R three times to the flight crew. The first occasion was when the Aircraft entered the base leg at a

distance of about 14.4 nautical miles from the extended runway centerline, and the second and third occasions were when the Aircraft was on the base leg at a distance of approximately 9.7 and 6.1 nautical miles, respectively. The Radar Controller provided three separate clearances for the ILS approach which gave the opportunity implicitly to the flight crew to review the ability of flying the Aircraft with the given tight vectoring for the approach. Should the flight crew have felt complex or impossible flying the radar vectoring, they could have declined it.

The trajectory of the approach vectoring was almost parallel to the initial straight IAF-IF line of the runway 14R ILS initial approach segment via the AMTAM waypoint as published in the LIDO chart.

EK131 was instructed to decrease airspeed from 180 to 170 knots, and maintain a 220-degree heading while descending to 3,300 feet pressure altitude (800 meters QFE) on the base leg.

During the initial approach, EK131 did not fly through the IAF (AMTAM) waypoint because it was provided with radar vectors by Radar control. Since AMTAM was a non-compulsory fly-by waypoint, depending on the traffic situation, the Radar Controller had discretion to provide vectoring with no obligation to manage the approach traffic through the IAF waypoint.

The vectoring for the approach resulted in a 2.9 nautical mile shorter flight track to the runway, compared to the track of the runway 14R ILS through the AMTAM waypoint (as shown in figure 4).

As the Aircraft neared the end of the arrival segment, at 1751:30, the Radar Controller offered the flight crew a descent to 500 meters QFE (2,230 feet QNH), whenever required, in order to establish on the localizer. EK131 was on the base leg at a distance of about six nautical miles from the extended runway centerline. At almost the same time, the Aircraft had started to level off at a pressure altitude of 3,300 feet as selected (approximately 800 meters QFE). The selected altitude was previously set at 3,300 feet, which was higher than the setting of 3,220 feet QNH (800 meters QFE) because of the altitude selection increment value of 100 feet, and was rounded upwards as per the Operator's procedure.

At this time, both autopilots, flight directors, and autothrust were engaged in 'altitude hold' / 'heading' / 'speed' modes. The 'glideslope' and 'localizer' modes had already been armed by using the approach pushbutton, and an airspeed target of 170 knots was selected. Both QNH settings were already at 1015 mbar, and the decision altitude (DA) was set to 800 feet. Runway 14R ILS was selected as the approach in the FMS, and the active point was DD142 (P) as the final approach point.

The ILS-DME distance of 10.2 nautical miles, was displayed on both NDs. The Commander and Co-pilot NDs were in ARC mode. The selected range was 10 nautical miles on the Commander's side and 20 nautical miles on the Co-pilot's side.

The landing system (LS) pushbuttons were activated on the Commander and Co-pilot sides, meaning that LOC and G/S deviation indications appeared when the localizer and glideslope signals were available.

The glideslope deviation indication was flickering above and below the 3º ILS glideslope as shown in figure 32, which means that the glideslope signal was still unreliable.

The slats/flaps were set to 'configuration 2'.

The flight crew agreed to descend to 500 meters QFE. The crew changed the altitude setting from 3,300 to 2,300 feet, which was rounded upwards (about 70 feet higher than the 2,230 feet QNH or 500 meters QFE) as per the Operator's procedure. The Aircraft stayed level at 3,330 feet QNH (800 meters QFE) for approximately 19 seconds before it commenced the

descent to 2,300 feet QNH. During this 19-second period, the offer of the descent to 500 meters QFE was made by the Radar Controller, and the Commander accepted the clearance.

The flight crew used an open descent mode by pulling the ALT knob on the automatic flight system control panel (AFS CP) which engaged the 'open descent' / 'heading' / 'thrust at idle' modes. The AP/FD adjusted the Aircraft pitch to maintain the selected 170 knots airspeed, while the A/THR managed idle thrust. The 'glideslope' and 'localizer' modes were still armed. At this time, the Aircraft was about 5.6 nautical miles from the extended runway centerline (final approach leg). The Aircraft started to descend to the target 500 meter QFE as planned for the ILS establishment.

During the descent, as the Aircraft was passing 3,090 feet pressure altitude, the landing gear lever was selected to the 'down' position while the Aircraft was almost abeam the AMTAM point. No speed limit was offered to the flight crew when there was adequate separation from following traffic as informed by the Radar Controller.

In the meantime, the DD142 (P) was sequenced, and subsequently the UUDD14R (runway 14R threshold) point became active. The sequencing of the DD142 (P) was automatically performed by the FMS, since 'heading' mode was engaged and the Aircraft was close to the DD142 point of the flight plan route. Until this point, the flight crew had followed the ATC vectoring.

2.2.2 The 212 degree heading selection

When the Commander read back the Radar Controller's instruction regarding no speed limit, a gradual change of the selected heading from 220 to 212 degrees occurred by rotating the HDG knob. The Co-pilot changed the heading to 212 degrees. The Commander was not aware of this heading change, as he only mentioned the 220-degree heading in his statement. The last heading instruction from the Radar Controller was to maintain 220 degrees to establish on the ILS. The Radar Controller did not issue an instruction to change the heading to 212 degrees. The flap lever position was changed from configuration '2' to '3'. The Commander configured the flaps as per the Co-pilot's request.

The Co-pilot then changed his ND range from 20 to 10 nautical miles in ARC mode.

At this time, the Commander became concerned about the 85-degree intercept angle and the speed of 170 knots, which he considered to be high. The Commander expected that the Aircraft would overshoot the localizer. He advised the Co-pilot to manage the airspeed, which was in accordance with the *FCOM* procedure.

The Co-pilot pushed the 'speed' knob, when the Aircraft was almost abeam the AMTAM waypoint and the target speed became 143 knots, which was the same as the target approach speed. Consequently, the airspeed started to decay slowly.

The instrument approach chart for the runway 14R ILS (figure A2.3) provides an interception of a 3-degree glideslope path at 3,220 feet QNH, with 8 nautical miles IDM DME, about 8.1 nautical miles from the runway 14R threshold.

Had a 220-degree heading been maintained as instructed, the Aircraft could have been expected to start turning left onto the final approach leg when its distance was between 1.2 and 1.5 nautical miles from FAP, and 8 nautical miles from the runway 14R threshold. The Aircraft could have been expected to intercept the localizer when its distance was between 7 and 7.2 nautical miles from the runway 14R threshold within the ILS azimuthal coverage during the left turn onto the final approach leg. This expectation could only occur if the Aircraft had levelled off at 500 meters QFE (2,300 feet QNH).

The heading change to 212 degrees, brought the Aircraft 0.4 to 0.5 nautical miles closer to the runway, compared with if the 220-degree heading was maintained.

Why the setting of 212-degree heading was selected, is described in subsection 2.2.9.

2.2.3 ILS glideslope deviation Indication

The glideslope deviation indication for the first approach showed that the Aircraft was above the 3º glideslope profile from 1752:00 to 1752:57, as given in figure 32.

The Aircraft never captured or established on the localizer, nor did it capture the glideslope.

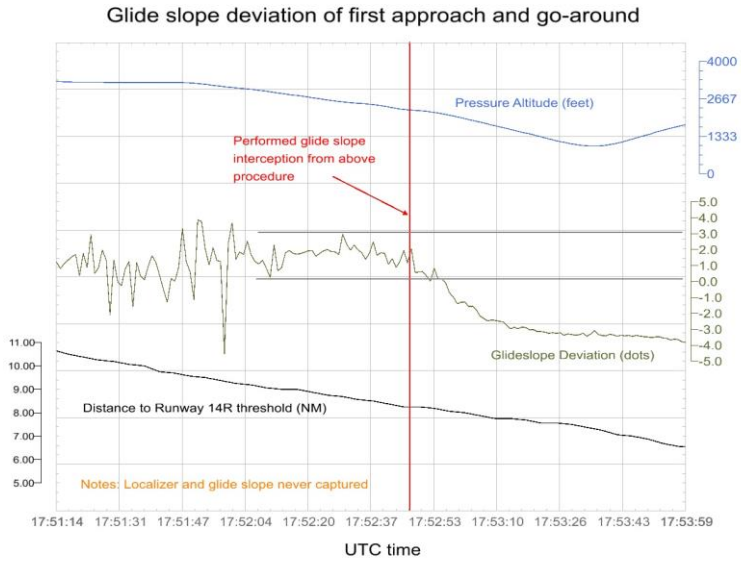


Figure 32. Glideslope deviation of the first approach and the go-around

Figure 33 shows selected Aircraft parameters as a function of the distance to the runway 14R threshold.

- Recorded barometric (pressure) altitude on the Commander side;
- Computed barometric altitude of a theoretical 3º glideslope;
- Computed barometric altitude by adding the glideslope deviation to the theoretical 3º glideslope. The recorded glideslope deviation in dots is converted to altitude deviation; and
- PSI angle represents the angle between the Aircraft position–runway threshold axis and the runway centerline axis, which enables identification of the point where the Aircraft enters the ICAO envelope denoting sufficient glideslope beam quality for a normal capture. (A statement about the envelope was provided in the *FCOM*).

At 1752:26, when the position of the Aircraft was abeam the AMTAM waypoint, following the noisy signal phase, the displayed glideslope deviation indicated that the Aircraft was above the 3-degree ILS glideslope, while the actual Aircraft height was approximately 580 feet below the theoretical 3-degree glideslope.

At approximately 1752:57, the displayed glideslope deviation indicated that the Aircraft was on profile, and continued descending below the profile. The actual Aircraft height was approximately 850 feet below the theoretical 3-degree glideslope when the glideslope

deviation indication indicated that the Aircraft was on profile. Following this, the actual Aircraft height continued to decrease.

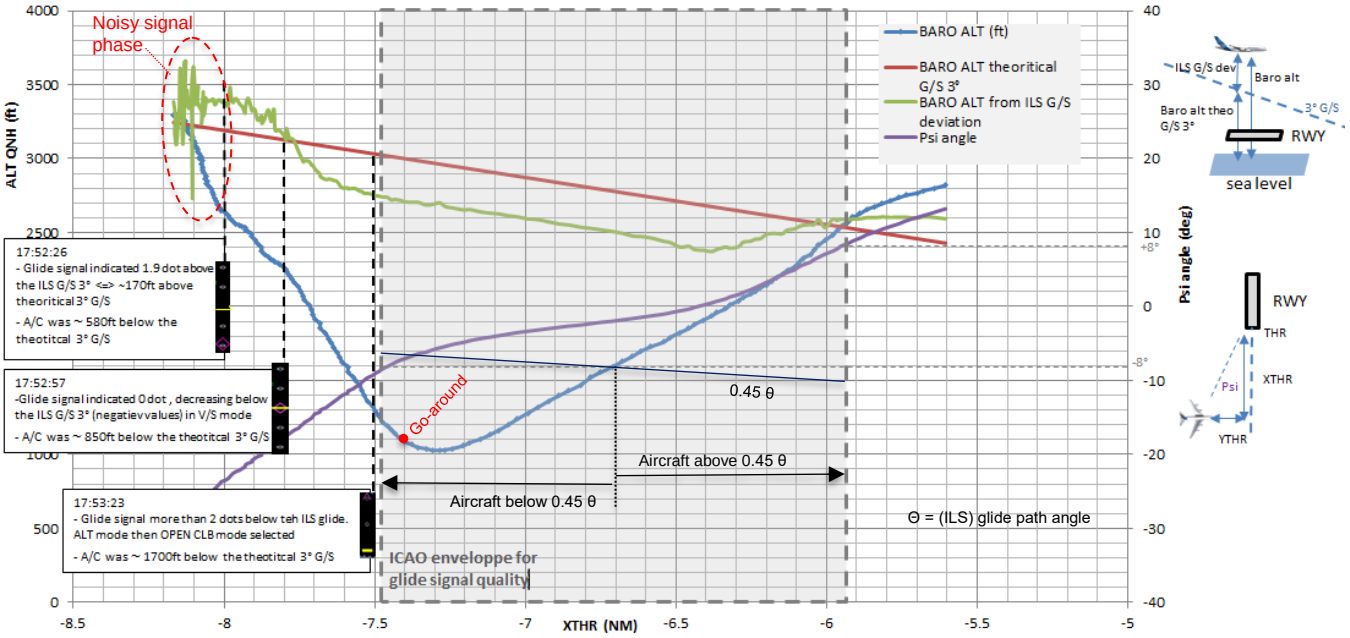


Figure 33. Selected Aircraft parameters as a function of the distance to the runway 14R threshold

Figure 33 illustrates selected Aircraft parameters as a function of the distance to the threshold of runway 14R. The difference between the recorded barometric altitude (blue line) and the computed barometric altitude derived from the recorded glideslope deviation data (green line) was significant, even within the ICAO envelope for the azimuthal coverage (purple line within 8 degrees left and right).

During the period of the first approach and go-around, the comparison between the computed barometric altitude of a theoretical 3 degree glideslope (red line) and the computed barometric altitude derived from the recorded glideslope deviation (green line), indicated that the ILS glideslope signal was inaccurate. However, in terms of direction, it behaved as expected during the descent by crossing the ILS 3-degrees glideslope from a higher to a lower altitude.

According to the minimum elevation coverage of the ICAO envelope, the Aircraft vertical position was below 0.45 θ (θ is the 3 degree ILS glideslope path angle) until the Aircraft' XTHR[19] distance reached 6.7 nautical miles, which occurred at 1753:54. The behavior of the computed barometric altitude derived from the recorded glideslope deviation (green line) was recovered in the correct direction when the XTHR reached 6.4 nautical miles, at 1754:04. This means that the recovery to a proper indication of the computed barometric altitude derived from the recorded glideslope deviation took about 10 seconds from the time when the Aircraft entered the ICAO envelope.

From the post flight report (PFR), no failure of either ILS receiver (multi-mode receivers 'MMR') was recorded, and the glideslope signals of both MMRs were almost identical.

Therefore, the Investigation concludes that the ILS glideslope signal was unreliable during the first approach and go-around since the Aircraft had entered the azimuthal coverage but it was outside the elevation coverage of the ICAO envelope, until 1753:54 (XTHR = 6.7

[19] XTHR is the distance between Aircraft position reflected on the runway centerline axis and the runway threshold

nautical miles). However, the runway 14R ILS ground system was in compliance with the minimum coverage of the ICAO envelope.

The ICAO envelope (see sub-section 1.17.8) was mentioned in the *FCOM*, but the lowest angle of elevation coverage (0.45 θ) was not mentioned in both Manufacturer's *FCOM* and Operator's *FCOM*. Although it was not a contributing factor in the Incident, the Investigation believes that stating the lowest angle of elevation coverage provides complete ILS coverage information for pilots.

During the course of the Investigation, the Operator took safety action regarding the ILS beam characteristics by including the lowest angle of elevation coverage in the *FCOM* in the Approach section. The Operator also trained the pilots and reviewed this Incident flight with a detailed explanation of localizer and glideslope design and use criteria, following the Incident.

In order to ensure sufficient glideslope beam quality for a normal capture for other operators, the Investigation recommends the Manufacturer to include the definition of the lowest angle for elevation coverage of the ICAO envelope in the *FCOM*.

2.2.4 Back to 170 knots selected mode

Approximately nine seconds after setting the airspeed to 'managed' mode, the Co-pilot selected the airspeed back to 170 knots gradually, by pulling the 'speed' knob and rotating it to 170 knots. Just before the selection of the new airspeed, the Aircraft was descending passing 2,560 feet pressure altitude (2,072 feet radio altitude), with a target of 2,300 feet pressure altitude, and the 'altitude hold' mode was armed. The airspeed was decaying through 163 knots (the target speed was 143 knots in a speed-managed mode). The localizer and glideslope modes were already armed. The landing gear was 'down and locked', and the flaps were set to 'configuration 3'.

Before selecting the airspeed to 170 knots, the flight crew were concerned that they were being vectored inside the final approach point (FAP/ P). The vectoring brought the Aircraft 2.9 nautical miles closer to the runway threshold, compared to the ILS 14R approach chart (figure 4) distance.

The flight crew expected the Aircraft to be at a distance of less than eight nautical miles from the threshold. In this case, the Aircraft would have been high on intercepting the glideslope when reaching the final approach leg. The Commander felt that the Aircraft was not in a comfortable position to turn and intercept the glideslope.

After setting the speed to 'managed' mode, the Co-pilot estimated that a higher airspeed than the target speed was required in order to expedite descent while in open descent mode. His perception of the need for a higher airspeed led him to select the airspeed to 170 knots.

After he selected the airspeed to 170 knots, the Co-pilot announced that he intended to maintain the 170-knot airspeed until the Aircraft was on the glideslope. The Commander stated that he became aware of the Co-pilot's action, but he did not question the purpose since he was distracted by the ATC communication that took place with other aircraft, and the announcement of the Co-pilot about his intention selecting back the airspeed to 170 knots.

Seven seconds later after 170 knots was selected, the altitude capture mode engaged indicating that the Aircraft had almost reached the selected 2,300 feet pressure altitude. At this time, the Aircraft was descending passing through approximately 2,470 feet. The displayed ALT* mode (in green) was indicated on the FMA for about seven seconds.

The 170 knots in selected mode did not have contribution to the descent below the vertical profile, as further analyzed in the following subsection regarding the application of *glide interception from above* procedure.

2.2.5 Performing the *glide interception from above* procedure

Approximately 14 seconds after the Co-pilot set the airspeed selected mode to 170 knots, at 1752:47, the selected altitude was increased from 2,300 to 3,000 feet, and thereafter the vertical speed was selected to -2,000 feet per minute.

As per procedure design, the selected altitude of 3,000 feet on the AFS CP was above the actual Aircraft altitude, which resulted in disengagement of the altitude capture mode and engagement of the vertical speed selected mode. At that time, the Aircraft was descending passing through 2,320 feet pressure altitude. The Aircraft should have been levelled off at 2,300 feet QNH (500 meters QFE), as instructed by ATC, but instead the Aircraft continued to descend since the *glide interception from above* procedure had been used.

The altitude target was selected above the Aircraft actual altitude as per *glide interception from above* procedure in order to prevent an inadvertent altitude capture engagement that would have destabilized the capture of the ILS glideslope (G/S) signal. It also prevents an attitude excursion in the case of a go-around initiation.

When the Co-pilot set the selected altitude to 3,000 feet, the pressure altitude on his primary flight display indicated 2,316 feet, and the altitude capture mode was still displayed on the FMA, giving him an opportunity, as the pilot flying, to remember the 2,300 feet QNH clearance as instructed by the Radar Controller, and to delay the application of the *glide interception from above* procedure. The altitude capture mode became disengaged and the display disappeared from the FMA after the selected altitude was set to 3,000 feet.

The Investigation believes that the Co-pilot referred only to the glideslope deviation indication displayed on the PFD that indicated more than one dot above the ILS glide profile (figures 27 and 28), while the ILS glideslope signal was not yet reliable and accurate. Had the Co-pilot referred to other vertical indications, it is most likely that he would not have performed the *glide interception from above* procedure. Therefore, the Investigation believes that before the Co-pilot decided to perform the procedure, he did not confirm the actual Aircraft vertical position by referring to other indications such as the pressure altitude, navigation and vertical display, and the approach procedure chart.

The vertical display (VD) was also available since both navigation displays (NDs) were in ARC and ROSE-NAV modes. Therefore, the Co-pilot could have referred to the VD to verify the actual Aircraft vertical position.

According to the *FCOM*, prior to commencing the *glide interception from above* procedure, the Aircraft should be established on the ILS localizer. When the Co-pilot performed the procedure actions, the Aircraft had not yet established on the localizer. The Aircraft was on the base leg at a distance of approximately 2.6 nautical miles from the extended runway centerline and 8.3 nautical miles from the runway 14R threshold. The Aircraft was properly configured as per the *FCOM*, as the slats/flaps were already set at 23º/26º (flap lever position at configuration 3) and the landing gear was extended.

As per the *FCTM* for this procedure, the vertical speed should be initially selected to -1,500 feet per minute, whereas the initial vertical speed was not stated in the *FCOM*. Both the *FCOM* and *FCTM* stated that the vertical speed should not exceed -2,000 feet per minute. The Co-pilot selected -2,000 feet per minute, as the maximum vertical speed.

Prior to performing the *glide interception from above* procedure, the Co-pilot believed that the Aircraft would have established on the localizer very soon. He saw that the localizer mode was already armed on the FMA. His concern, during the period between setting the airspeed to 170 knots and performing the *glide intercept from above* procedure (within 14 seconds), was related to the Aircraft being high as indicated by the invalid glideslope deviation indication. To rectify this perceived situation, the Co-pilot intended to reduce the airspeed after the Aircraft had captured the glideslope. The Investigation believes that his intention to reduce

the airspeed was to manage the Aircraft's energy after capturing the glideslope, such that it would not have created additional workload.

Calculations performed by the Investigation, based on the groundspeed, indicate that the Aircraft would have established on the localizer approximately 63 seconds from the time the Co-pilot selected the altitude to 3,000 feet. However, establishing on the localizer would only have occurred if the Aircraft had maintained 500 meters QFE (2,300 feet QNH) as instructed, and it was not the case in this Incident.

The Co-pilot stated that his expectation was that the Aircraft would establish on the localizer within three to four seconds, after performing the procedure. The Co-pilot's action in attempting to join the glideslope from above was because of the false indication that the Aircraft was high due to the invalid glideslope deviation, and his perception that the Aircraft would be established on the localizer very soon. In fact, the Aircraft was already below the 3-degree glideslope, and the Aircraft would have established on the localizer considerably later than his three to four second expectation (as calculated, it would have been approximately 63 seconds after the initiation of the procedure).

Due to the Co-pilot's false perception that the Aircraft was high, he had to act (to perform the *glide intercept from above* procedure) quickly. He did not action the SOP correctly, as he did not ensure that the Aircraft was established on the localizer prior to performing the procedure. In addition, he did not monitor the improvised glide capture maneuver by referring to the biased glideslope signal displayed deviating towards the profile and continued descending to two dots below the ILS glideslope. After the glideslope deviation went below the profile, the Co-pilot did not take assertive action to recover the Aircraft, or at least take action to bring the Aircraft on profile. The glideslope deviation continued, descending to in excess of two dots below the profile. The maximum displayed scale on the PFD was two dots.

The localizer mode was in the 'arm' condition when the Co-pilot performed the procedure, and the mode should go through the capture condition first, before establishing on the localizer.

The *glide interception from above* procedure was part of the normal *FCOM* procedures and there was no requirement, nor was it feasible for the flight crew to reference the documentation prior to the application of the procedure. As such, it is expected to be performed from memory. In this event, the Co-pilot was aware of the required conditions for the procedure (the prerequisite to establishing on the localizer). However, due to his false perception that the Aircraft would be established on the localizer very soon, about 3 to 4 seconds as claimed by him, he commenced the procedure when the Aircraft was not yet established on the localizer. With the exception of the required prerequisite conditions, the Co-pilot continued the sequence of the procedure. The Investigation believes that the Co-pilot's perception of the need for urgency and his expectation bias[20] that the Aircraft would establish on the localizer very soon caused him to perform the procedure without following the prerequisite conditions as per the *FCOM*.

In addition to the Co-pilot's concern about the tight approach and the high Aircraft position from the invalid displayed glideslope deviation, he also received input from the Commander such that both flight crewmembers felt that the Aircraft was too high and would still have been high on the glideslope intercept angle when it reached the final approach path.

Four seconds elapsed from when the Co-pilot set the selected altitude of 3,000 feet to the time when he selected the vertical speed to -2,000 feet per minute. Then, after he set the vertical speed, the Radar controller contacted the Aircraft at 1752:51, and instructed the flight crew to maintain the present heading to establish at the final approach point (P) at 500 meters, and to contact the Tower at 118.6 MHz. This radio contact took 11 seconds. The

[20] Expectation bias is defined as having a strong belief or mindset towards a particular outcome.

Aircraft was descending on the 212-degree heading. The Radar controller, probably, knew that the Aircraft was already on that heading. The other possibility is that the Radar Controller thought that the Aircraft was still on a 220-degree heading, and the instruction to maintain the present heading meant to maintain the 220-degree heading, since the previous heading instructions had referred to 220 degrees (the 220-degree heading was explicitly instructed two times).

At the beginning of the Radar Controller's transmission, the Aircraft was descending just below 2,280 feet pressure altitude (approximately 500 meters QFE), as indicated on the Co-pilot's PFD. During these 11 seconds, and as the Radar controller was providing instructions, the Co-pilot changed the selected heading from 212 to 211 degrees. During the final part of the instruction, he again changed the selected heading from 211 to 210 degrees.

The time between these two heading changes was about six seconds. It is likely that the Co-pilot focused on the heading to establish on the ILS during the period after performing the procedure. His action of small heading corrections was performed to ease the capture of the localizer, since the UUDD14R (runway 14R threshold) point had already become active as displayed on the FMS. It was approximately in the middle of the Radar Controller's instruction that the glideslope deviation indication showed on profile and continued descending below the ILS glideslope profile. Once the target speed was adjusted and the *glide interception from above* procedure was initiated and the small heading corrections were made, the Co-pilot, as the pilot flying, did not monitor the glide capture by the AFS as per the approach SOP. This SOP required a check of the glideslope capture mode engagement by AFS when the glideslope deviation went close to null deviation (on profile), and to take over when the glideslope deviation was continuing to increase beyond the PFD's scale. Consequently, he allowed the displayed glideslope deviation to cross almost the full scale from above to below without an engagement of the glideslope capture mode. The Co-pilot's improvisation in performing the *glide interception from above* procedure did not help the Commander, as the pilot monitoring, to adapt the monitoring function to cope with this particular maneuver.

The Co-pilot stated that during the 11-second period, he simultaneously announced his actions in performing the *glide interception from above* procedure to the Commander, but the Commander did not acknowledge. It revealed that the Co-pilot did not adhere to the instruction of the Radar controller to maintain the present heading and to establish approaching the final approach point (P) at 500 meters, since he changed the selected heading from 212 to 210 degrees in two steps (212 to 211 degrees was set first, then 211 to 210 degrees).

After setting the heading to 210 degrees, the Co-pilot then requested the Commander to set the flap lever position to configuration 'full'. The Co-pilot's request was made during the six-second time period between the Radar Controller's radio contacts.

Note: The first contact was the 11-second period (from 1752:51 to 17:53:02) Radar's instruction to maintain the present heading of 220 degrees and providing a QNH setting of 1015 mbar. The second Radar Controller's contact (at 1753:08) by calling "*UAE 131*" came as no reply had been received from the flight crew. The time between the end of the first contact and the beginning of the second contact was six seconds. The Commander then replied the second Radar Controller transmission "*Go ahead UAE 131*".

During the 11-second period of the first radio conversation, the Commander directed his attention to Radar Controller's instructions while trying, at the same time, to understand the Aircraft state.

This six-second period was adequate for the Commander to read back the first radio contact, but the Commander did not reply to the Radar Controller because he was distracted by the Co-pilot's request to set the flaps setting to 'full' position.

Since there was no reply, the Radar Controller again contacted the flight crew for the second time and the Commander replied. Immediately after responding to the Radar Controller's call, the Commander moved the flaps lever position to 'full' as requested by the Co-pilot.

The Radar Controller then contacted the crew (third contact from 1753:11 to 1753:28) urgently providing further instruction to terminate the descent as the Aircraft had descended below 500 meters.

After the first Radar control's contact, the radio frequency had not yet been changed to the Tower control frequency, as previously instructed by the Radar Controller due to the high workload that the Commander had.

The situation, as it developed, may have affected the Commander's awareness especially his appreciation of the actual Aircraft vertical position. It is likely that he did not refer to the indications available to him of pressure altitude, navigation and vertical display, nor did he observe the indication of the glideslope deviation when it went towards the profile and continued below the ILS glideslope. After the second Radar control's contact, the Commander felt that he needed to reply the Radar Controller.

The Commander stated that he did not recognize the Co-pilot's announcement about his (Co-pilot's) actions as he attempted to carry out the *glide interception from above* procedure.

During the time between the Radar Controller's first instruction and his second communication, the Commander was confronted with a significant workload including:

- the need to change the radio communication frequency to the Tower control;
- understand the change of heading to 210 degrees, which was not as instructed;
- the Co-pilot's announcement of the *glide interception from above* procedure that the Commander did not understand, if indeed such an announcement was declared by the Co-pilot;
- the second Radar Controller's communication, which required a reply from the Commander; and
- the request to set the flap lever from '3' to 'full' position from the Co-pilot, which occurred within the six-second period, or between Radar Controller's second communication and the Commander's reply.

The flight crew were unaware that the Aircraft had descended below 500 meters. The Commander was attending to the workload listed. The high workload resulted in the Commander not replying to the Radar Controller's initial instructions, and his only action was to set the flap lever to 'full'.

Since the radio frequency had not yet been changed to the Tower control frequency, the Radar Controller was still able to alert the flight crew to the situation. Should the frequency have been changed to the Tower frequency, it might have resulted in a more serious outcome since the time at which the first contact would have made with the Tower could not be predicted, and the Tower Controller would have needed some time to comprehend the true Aircraft situation, including its vertical position.

The Co-pilot was performing the *glide interception from above* procedure, expecting the Aircraft to capture the localizer soon. He was also concentrating on the Aircraft heading and the landing configuration.

In this period, both flight crewmembers were in a high workload condition and they were focused on what they were immediately doing, which affected communication between them and degraded their situational awareness[21].

The Co-pilot could not recall whether he attempted a second time to announce his actions to join the glideslope from above after he had not received an acknowledgement from the Commander.

The Commander stated that the Co-pilot mentioned the 90-degree localizer interception angle during the approach briefing. They did not discuss the *glide interception from above* procedure during the approach briefing, since it is a contingency procedure that is applied as the situation dictates.

The 90-degree turn onto the final leg was a known threat at UUDD, hence it was documented in the Operator's crew critical information (CCI) pages. There was a possibility that the aircraft would become high on profile as the ATC radar vectors were provided. Therefore, it was not systemic and, as such, not documented, and thus not anticipated by the crew. However, the Radar Controller offered the flight crew a descent to 500 meters QFE to establish on the ILS, when required. The ATC offer was to provide the flight crew with a choice of selecting the required altitude for the Aircraft to establish on the localizer, and to intercept the glideslope. The Commander chose to descend to 500 meters QFE (2,300 feet QNH), which indicates that he planned to establish on the localizer and to intercept the glideslope at 2,300 feet QNH.

When the Aircraft was on the base leg, the Commander advised the Co-pilot that the Aircraft would be above the glideslope when established on the localizer, and the possibility to perform the *glide interception from above* procedure. The Co-pilot agreed, and he replied that they might use the *glide interception from above* procedure.

However, as per the Commander's statement, no verbal notification took place by the Co-pilot when he performed the *glide interception from above* procedure.

Since the CVR recording of the Incident flight was not available to the Investigation, it was not possible to determine:

- whether any verbal announcement on performing the *glide interception from above* procedure took place by the Co-pilot;
- whether the Co-pilot stated a second time that he applied *glide interception from above* procedure, after he had not received a confirmation from the Commander to his first announcement; and
- when precisely the Commander alerted the Co-pilot that the Aircraft would be high when established on the localizer.

The Commander's alert to the Co-pilot that the Aircraft would be high on the glideslope could have been issued between the time when the Radar Controller provided the ILS clearance for the second time, including the instruction of 170 knots airspeed (after 1750:12) and the time when the Commander requested to descend to 500 meters QFE at 1751:36.

The glideslope deviation indication went through the profile at 1752:57 and thereafter continued to move below the IDM 3-degree ILS glideslope (figures 27 and 28).

[21] Situational awareness is a human perceptual state in which information is gained from the environment through many processes. These processes are believed to be the perception of environmental elements, the comprehension of their meaning and the projection of their status following a change in a variable (such as time) (Endsley, 2005).

At 1752:51, the Radar Controller contacted EK131 and this might have distracted the Commander attention from the *glide interception from above* procedure performed by the Co-pilot, which was initiated four seconds before Radar control's contact.

From 1752:12 to 1752:34, the glideslope deviation indicated about 1.9 to 2 dots above the IDM 3-degree ILS glideslope. Between 1752:34 and 1752:57, the deviation was still indicated above the profile, but less than 2 dots.

When the ILS deviation indication was on profile, the Aircraft was descending through 2,200 feet pressure altitude. After crossing the IDM 3-degree ILS glideslope (after 1752:57), the glideslope deviation indicated below the 3-degree ILS glideslope for about 9 seconds before reaching a deviation of 2 dots. Following this, the display continuously indicated a deviation of 2 dots below the 3-degree ILS glideslope, since the indicator was out of scale.

After the glideslope deviation indicated that the Aircraft was below the profile, the Investigation believes that the Commander did not refer to his glideslope deviation indicator, nor to other indicators such as pressure altitude, the navigation and vertical display, or the approach procedure chart.

The ICAO envelope of glideslope signal coverage is basic knowledge for an instrument rated pilot. Guidance for runway 14R ILS was provided in a LIDO chart, and in the *FCOM*. It is also referenced in the Manufacturer's pilot development program (PDP), which was mandatory for new pilots joining the operator. However, there was no evidence that either flight crewmember was aware of the ICAO envelope of glideslope signal quality. The angle of the Aircraft-runway threshold axis relative to the runway centerline axis (psi angle of figure 33) was approximately 18.5 degrees, which was more than 8 degrees. Based on the flight path, the Aircraft passed 8 degrees psi at about 1753.25, which means the flight crew might have needed to wait for another 38 seconds from the time the selected altitude was set to 3,000 feet (initiation of the *glide interception from above* procedure), in order to obtain normal quality of glideslope signal as per ICAO envelope.

Had the flight crew been aware of the envelope, they most likely would have crosschecked the unreliable glide signal information by referring to the pressure altitude and the estimated distance to the runway threshold when the localizer course will be intercepted using DME and/or ND indications to identify the correct altitude required to position the Aircraft on the 3º ILS glideslope. Therefore, both flight crewmembers may have been satisfied after capturing the 2,300 feet QNH altitude instructed by the Radar Controller or may have prevented the Co-pilot, as the pilot flying, the urgency to improvise the *glide interception from above* procedure.

A good practice when the Aircraft was still far from the localizer course is to anticipate the Aircraft vertical position with respect to the glide when the localizer course will be intercepted is to:

- Estimate the distance from runway threshold when the localizer course will be anticipated by using DME and/or ND (extended centerline displayed);
- Estimate the altitude of the 3º glideslope at this distance using the 300 feet per nautical mile rule of thumb or reading the approach chart when ILS/DME table is included.

During on the base leg, estimating the distance from runway threshold of the expected localizer course, could have been crossed by looking to the navigation display (ND) and using the 300 feet per one nautical miles thumb rules, or referring to the Approach Chart (ILS 3º Altitude – DME Table). These are the basic ways to determine the required altitude to intercept the localizer course with Aircraft positioned closely the 3º glideslope.

Crosschecking the actual Aircraft altitude and/or the new altitude given by the Radar Controller, would have ensured a good estimate of the anticipated Aircraft vertical position with respect to the 3º glideslope when the localizer course have been intercepted. It would also have provided an independent check with respect to a potentially unreliable glide signal. In addition, this crosscheck might have avoided the flight crew to maintain the false perception that the Aircraft would be above the glideslope when intercepting the localizer, despite the ATC clearance to descend to 2,300 feet QNH during the base leg.

The Investigation believes that the Commander, as the pilot monitoring, was concentrating on communications with ATC to such an extent that his situational awareness of what was occurring in the cockpit and of the actual Aircraft state was significantly degraded. He was aware of the airspeed and he proposed setting 'managed mode', and he expected that the Aircraft would intercept the glideslope from above, as he believed that the Aircraft was too high, since he referred to the glideslope deviation indication. However, he did not challenge the Co-pilot as to the Co-pilot's application of the *glide interception from above* procedure. The Commander, probably, relied on the Co-pilot to an extent that he degraded his own situational awareness, especially in relation to the Aircraft state. He focused more on communications and in helping the Co-pilot to configure the Aircraft for the approach and landing when requested by the Co-pilot.

Neither pilot was aware that the Aircraft was descending below 500 meters QFE until the instruction 'not to descend further' came from the Radar Controller. On receiving this instruction, the Commander then decided to initiate an immediate go-around. He declared his intention to the Radar Controller approximately three seconds after the "not to descend" instruction.

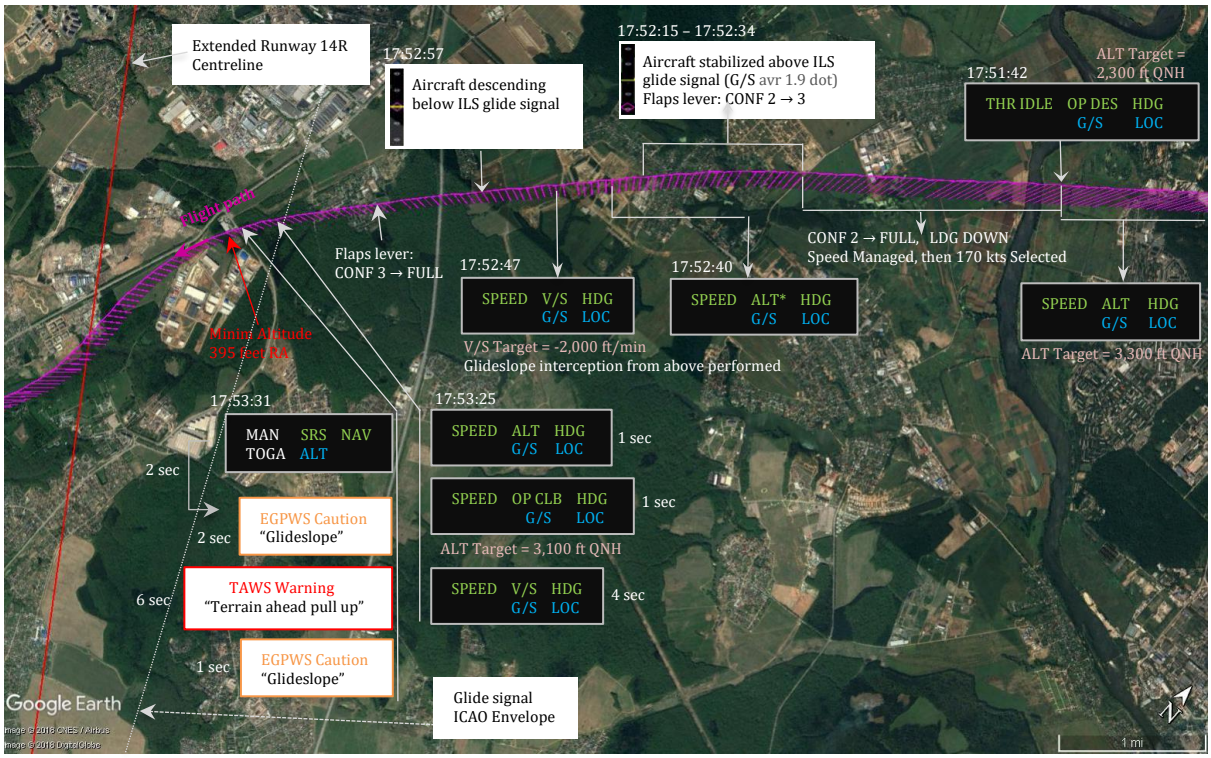


Figure 34. Aircraft trajectory of the first approach and the go-around

The Commander did not observe the Co-pilot making entries in the AFS CP such that he could not have recognized that the Co-pilot initiated the *glide interception from above* procedure. The Commander became aware of events after the go-around, only when he asked the Co-pilot what had happened before the go-around was initiated. After the Co-pilot's explanation that he had performed the *glide interception from above* procedure, the

Commander then commented that the Aircraft needed to be on the localizer before performing the procedure.

When performing the *glide interception from above* procedure, the Co-pilot, as the pilot flying, set 3,000 feet as a target altitude. The target altitude was set above the current Aircraft altitude. At this time, the Aircraft was descending through 2,320 feet QNH. Setting the target altitude above the Aircraft altitude, removed an altitude barrier and allowed a continued descent below the cleared altitude (500 meters QFE).

Setting a higher altitude was in line with the SOP, however, the *glide interception from above* procedure should only be applied when the Aircraft has established on the localizer. This also means that the Aircraft should have been inside the certified ILS envelope. Therefore, the glideslope serves as a defense barrier to prevent an inadvertent descent below the profile. The setting of a higher altitude was to prevent an altitude excursion in case of a go-around initiation, and to prevent a premature altitude capture prior to the glideslope intercept.

Applying the *glide interception from above* procedure when the localizer is not yet established, in a degraded situational awareness, may have a result in descending continuously below the lowest angle of elevation coverage of the ILS envelope, and never capturing the glideslope that means loss of the glideslope profile as a defense barrier, as what happened in this occurrence.

The Investigation believes that the term “should” in the *FCOM* procedure was not strong enough to emphasize the threat when the procedure was applied outside the certified ILS envelope.

Following the Incident, during the course of the Investigation, the Operator took action by revising the *FCOM* and the *FCTM* to ensure that the SOP explains that the *glide interception from above* procedure must only be applied when established on the localizer. The revision also includes that applying the procedure is only authorized down to the charted FAF/FAP, the charted Descent Point or the ATC cleared approach intercept altitude.

For other A380 aircraft operators, in order to ensure performing the procedure accurately, the Investigation recommends that the Aircraft manufacturer emphasize the necessity of ensuring the aircraft establishment on the localizer, as a mandatory prerequisite action to apply the *glide interception from above* procedure.

2.2.6 The go-around

At 1753:11, the Radar Controller instructed EK131 to stop its descent. The Radar Controller’s transmission of this instruction lasted for approximately 17 seconds. As this communication started, the flap lever was set to ‘full’. In addition, in the middle of the communication, the selected heading was changed from 210 to 188 degrees, which was carried out by the Co-pilot.

The Investigation believes that, within these 17 seconds, it was the Commander, who realized the true situation regarding the Aircraft vertical position, which was already less than 500 meters above ground level. Later, the Co-pilot understood the situation because the Commander urgently directed ‘select ALT’ twice.

Based on the FDR data, ATC transcript, and the Co-pilot’s statement, the Commander queried the Co-pilot about the selection of altitude hold mode during the final part of the Radar Controller’s instruction. The Co-pilot then realized that the Commander’s query was urgent. This caused the Co-pilot to press the ALT pushbutton approximately three seconds before the Radar Controller’s instruction ended in order to stop the descent by levelling off the Aircraft. At this time, the Aircraft was descending passing 707 feet radio altitude with a rate of descent approximately 2,000 feet per minute.

This means that, until this time, the Co-pilot was not paying attention to the Radar Controller's last instruction and he was most likely only aware of the Aircraft's heading to establish on the ILS establishment. The Co-pilot only became aware of the urgency of the situation when the Commander asked him to select 'altitude hold' mode.

One second later, the Co-pilot rotated the altitude knob to 3,100 feet and pulled the knob, which engaged the 'open climb' mode only for one second, then he pulled and rotated the vertical speed knob from -2,000 to +2,500 feet per minute. The last action resulted in 'vertical speed' mode and 'speed' mode engagement. Immediately after this, the Commander decided to initiate a go-around and the Co-pilot then commenced the go-around by pushing the thrust levers to the TOGA detent, and then moving the thrust levers back to the FLEX MCT detent four seconds later, which initiated a soft go-around. Hence, the speed reference system managed mode, navigation mode, and manual go-around soft mode became engaged as were displayed on the FMA.

When the go-around was initiated, the Aircraft was descending and passing through 504 feet radio altitude with a rate of descent approximately 1,600 feet per minute.

The elapsed time from the Commander's decision to carry out a go-around and the initiation of the go-around was approximately three seconds, after the end of Radar Controller's instruction to stop any further descent.

At the time of the initiation of the go-around, the localizer track mode and/or localizer capture mode did not engage and so neither the glideslope track nor the glide slope capture modes. This was in line with the system design logic, which decreased the risk of a glideslope capture mode or glideslope track mode engagement when the Aircraft position was outside the ICAO envelope where the glideslope signal quality could not be assured.

The system logic ensured that the glideslope capture occurred within the lateral limits of the ICAO envelope where the glideslope beam quality was adequate. In this case, the Aircraft was below the minimum elevation coverage of the ICAO envelope (below 0.45 θ, θ is the 3 degrees of ILS glideslope path angle), however, the Aircraft was within the lateral limits of the envelope. This caused the localizer capture mode and/or localizer track mode to fail to engage.

The go-around phase was activated in the FMS, and the runway 14R ILS missed approach became active in the flight plan, separated by a discontinuity with an automatic runway 14R ILS approach re-strung, as per design.

Approximately two seconds later after initiating the go-around, the glideslope alert appeared for approximately two seconds, followed by a "Terrain ahead, pull up" aural warning that lasted for six seconds and finally for one second a further "Glideslope" alert.

The localizer deviation indications on both PFDs were far from the axis (+/- 2 dots), and the Aircraft was below 1,000 feet, which triggered the "Descent below glideslope (mode 5)" cautionary alert, and therefore the "Glideslope" aural alert sounded and the visual alert appeared on the PFD.

The terrain awareness display (TAD) warning alert had priority over the glideslope 'mode 5' cautionary alert. In this case, the TAD cautionary alert did not appear before the TAD warning. This condition occurred, most probably, due to the edge of the TAD caution envelope being overlaid by the edge of the TAD warning envelope to ensure that warnings take precedence over cautions. The TAD warning triggered the activation of the "Terrain ahead, pull up" aural alert and the 'Terrain' visual alert on both NDs.

The minimum radio altitude of the Aircraft was 395 feet above the ground level while the alerts (caution and warning) were active. This means that the Aircraft had an altitude loss of approximately 109 feet after initiation of the go-around.

The Aircraft descended through 474 feet when the two-second “Glideslope” caution started. The six-second “Terrain ahead, pull up” warning appeared shortly after the Aircraft reached 395 feet when the Aircraft started to climb, and it ended or changed to “Glideslope” caution, when the Aircraft climbed through 498 feet. The final one-second “Glideslope” caution ended when the Aircraft climbed through 547 feet.

After the go-around, the flight crew requested radar vectoring for a longer final approach to runway 14R.

2.2.7 Planning the ILS 14R approach based on the ATC vectors

When the Aircraft was on the base leg in the final part of the arrival segment, the Radar Controller provided clearance for the runway 14R ILS and instructed EK131 to turn onto a heading of 230 degrees and to descend to 800 meters (3,220 feet QNH). This was about 4 minutes 50 seconds before initiation of the go-around. The Aircraft was descending passing 5,788 feet pressure altitude on a 240-degree heading on the base leg, about 14.4 nautical miles from the extended runway centerline (final approach leg). There is a possibility that at this time the flight crew were not yet aware that the Aircraft would not overfly the AMTAM fly-by waypoint as the initial approach fix as per the chart.

About 48 seconds later, the Radar Controller instructed EK131 to turn onto a heading of 220 degrees, as the Aircraft was descending passing through 4,892 feet pressure altitude on a 230-degree heading on the base leg, approximately 11.9 nautical miles from the extended runway centerline (final approach leg). This was about four minutes before the go-around decision. The Investigation believes that after this instruction, both pilots should have been aware that the Aircraft would not overfly the AMTAM waypoint and that the flight path would be closer to runway 14R. Had they become aware of this situation, four minutes would have been available to the flight crew to plan intercepting the ILS. However, since the CVR data was not available, the Investigation could not determine accurately how they had discussed a plan of required action(s) to address their concern about the tighter approach and the high Aircraft position.

The instrument approach chart for the runway 14R ILS provided an interception of the 3-degree glide path at 3,220 feet, a distance of 8 nautical miles IDM DME, meaning 8.1 nautical miles from the runway 14R threshold. When the Aircraft was at the end of the arrival segment, at 1751:30, the Radar Controller provided EK131 with an option to descend to 500 meters QFE (2,230 feet QNH), whenever required, in order to establish on the localizer. The Investigation believes that the flight crew should have planned their action(s) at this time, as it was the final occasion available during which to plan the approach. The flight crew still had about two minutes to plan before the Aircraft reached the final approach leg.

Had the flight crew decided to level the Aircraft at 3,300 feet until the final approach leg, with the given approach vectoring and the instructed 220 degrees heading, the Aircraft could have been expected to cross the extended runway centerline (135 degrees inbound course of runway 14R ILS) at 6.5 - 7 nautical miles from the runway threshold. The distance is estimated after turning from the base leg onto the final approach leg. In this case, the Aircraft would have been approximately 480 feet (3,300 feet versus 2,820 feet) above the theoretical 3-degree ILS glideslope.

Referring to the LIDO runway 14R ILS chart (figure A2.3), the Aircraft could have been at approximately 390 feet above the 3-degree glideslope.

The Commander had decided to descend to 2,300 feet to establish on the ILS. With the given approach vectoring, and maintaining the instructed 220-degree heading, the Aircraft would have crossed the extended runway centerline 6.5 - 7 nautical miles from the runway threshold. In this case, the Aircraft would be approximately 520 feet (2,300 feet versus 2,820 feet) below the theoretical 3-degrees ILS glideslope.

Referring to the ILS 14R chart, the Aircraft would be at approximately 610 feet below the 3-degree glideslope.

The actual 3-degree ILS glideslope of UUDD ILS 14R, as given on the LIDO ILS 14R chart, was between 80 and 100 feet higher than the theoretical 3-degree ILS glideslope.

On the final part of the arrival segment, the condition of the ILS glide signal was not yet stable. At around this time, the Co-pilot changed the heading from 220 to 212 degrees, which the glideslope deviation indication showed above the profile. The Aircraft was descending just passing 3,000 feet pressure altitude. The Co-pilot's perception that the Aircraft was high continued when the glide deviation indication showed above the profile. The Co-pilot did not observe the glideslope deviation indication when it went through the profile and continued descending to the maximum displayed scale indication of two dots below the profile.

Besides the Co-pilot's perception that the Aircraft needed to establish on the localizer as soon as possible, the Investigation also believes that the Aircraft indication above the profile was the reason for the Co-pilot to set the 170 knots speed back to 'selected' mode from speed 'managed' mode, and then to perform the *glide interception from above* procedure.

2.2.8 The difference between the speed 'managed' mode and the speed 'selected' mode of 170 knots

The Radar Controller provided no speed limitation when the Aircraft was on the base leg approximately 4.2 nautical miles from the extended runway centerline (final approach leg). This gave the opportunity to the flight crew to manage the Aircraft such that localizer establishment and glideslope interception, normally from below, could be acquired on the inbound course of the runway 14R ILS (final approach segment).

The investigation calculated the difference between the use of speed managed mode compared with the selected speed of 170 knots as flown. The calculation is based on the actual groundspeed.

2.2.8.1 Speed 'managed' mode

The calculation if using speed 'managed' mode is given in sub-section 1.18.2.1 of this Report.

When speed managed mode was set, at 1752:24, the Aircraft was approximately abeam of the AMTAM waypoint, 3.6 nautical miles from the runway centerline axis (inbound course of 14R ILS). The Aircraft was descending through 2,712 feet pressure altitude.

Had the speed 'managed' mode been used and maintained, the airspeed of 143 knots would have been reached 21 seconds after engagement of the speed 'managed' mode setting, and would have resulted in a distance of 0.82 nautical miles. The Aircraft position would have been approximately 2.78 nautical miles from the inbound course of the runway 14R ILS. The Aircraft would have levelled off at 2,300 feet QNH (≈2,712 - 412 feet) about 8 seconds after the target airspeed of 143 knots was reached, and would have intercepted the inbound course at approximately 6.5 nautical miles from the threshold of runway 14R.

With an assumption of constant wind, and the *glide interception from above* procedure not applied, and the Aircraft levelling at 2,300 feet QNH (about 500 meters QFE), the required time for the Aircraft to reach the inbound course of the runway 14R ILS from the distance of 2.78 nautical miles, would have been approximately 78 seconds. Therefore, the Aircraft could have been expected to be flying on the inbound course of the runway 14R ILS in 99 (≈ 21 + 78) seconds, had the speed 'managed' mode been set at 1752:24 and remained set.

2.2.8.2 Airspeed 'selected' mode of 170 knots

When the airspeed was selected to 170 knots, at 1752:33, the Aircraft was approximately 3.2 nautical miles from the inbound course of runway 14R ILS, while descending through 2,560 feet pressure altitude.

Had the *glide interception from above* procedure not been applied, the Aircraft would have reached 2,300 feet QNH (about 500 meters QFE) after flying for approximately 17 seconds over a distance of 0.7 nautical miles, which would have placed the Aircraft approximately 2.5 nautical miles from the inbound course of runway 14R ILS. The airspeed would have been 162 knots.

From this point until the airspeed reached 170 knots, it would have taken 12 seconds over a distance of 0.5 nautical miles.

With the assumption that the Aircraft followed the same flight path and maintained 2,300 feet QNH (approximately 500 meters QFE), the required time to reach the inbound course of runway 14R ILS from when the Aircraft is at 2.0 nautical miles, would be approximately 48 seconds. Therefore, the Aircraft could have reached the inbound course of runway 14R ILS 77 (≈ 17 + 12 + 48) seconds after the setting of 170 knots as the selected airspeed at 1752:33.

As planned by the Co-pilot, the airspeed would have been reduced when the Aircraft established on the localizer.

For the Aircraft to reach 500 meters QFE over a distance of 6.5 nautical miles from the threshold on the inbound course of runway 14R ILS, the difference between the 170 knots 'selected' mode and the speed 'managed' mode would have been approximately 13 seconds. The 170 knots selected mode may have been quicker than the speed 'managed' mode. However, at this position, the airspeed would have been at 170 knots for the speed 'selected' mode, and at 143 knots for the speed 'managed' mode.

Based on the theoretical calculation of a 3-degree glide path, over a distance of 6.5 nautical miles, the height would be approximately 2,660 feet QNH. For the same distance of 6.5 nautical miles, referring to the ILS 14R chart, the altitude of 3-degrees glide path would be approximately 2,750 feet.

Therefore, the Aircraft may have been between 430 and 520 feet[22] below the glideslope at a distance of 6.5 nautical miles from runway 14R threshold, when it reached the inbound course.

With an airspeed of 170 knots, at a height of 500 meters and a distance of 6.5 nautical miles from the threshold, the Investigation believes that the flight crew may still have had time to reduce the airspeed, including use of the speed brake, while maintaining 500 meters until the glideslope interception. Without performing the *glide interception from above* procedure, the Aircraft would have captured the glideslope normally from below. The Investigation concludes that the vector 14R ILS approach provided by the Radar Controller was feasible and realistic for the Aircraft since 500 meters QFE on the localizer establishment would have resulted in capturing the glideslope from below, as long as proper final vector (heading) is provided such that an intercept angle with the final approach track of 45 degrees or less can be obtained.

The Investigation believes that if the *glide interception from above* procedure had not been applied, and when the Aircraft was within the azimuthal coverage of the ICAO envelope, the Aircraft might have been in a position such that a correct glideslope signal could have been obtained because the Aircraft may have been within the elevation coverage of the ICAO

[22] 500 meters QFE = 2,230 feet QNH
2,660 - 2,230 = 430 feet (based on Investigation calculation of 3 degrees glide path)
2,750 - 2,230 = 520 feet (refer to ILS 14R chart)

envelope. Therefore, the flight crew may have received a correct glide deviation indication, even if the glideslope deviation indication was the only reference they used.

2.2.9 Interpretation of Aircraft high position

The Investigation believes that the Co-pilot was cognitively fixated on the Aircraft's high position interpretation since he referred to the glideslope deviation indication, while the Aircraft was actually descending below the 3-degree ILS glideslope and this coincided with his inappropriate assumption that the Aircraft would establish on the localizer very soon. Due to his false interpretation of the situation, his next action was to descend the Aircraft as soon as possible using an inappropriate procedure.

The Co-pilot stated that when the Radar Controller instructed a change to the Aircraft heading from 230 to 220 degrees, at 1749:29, he felt that it looked that the Aircraft was quite close into the runway. At this time, the Aircraft was on the base leg about 11.9 nautical miles from the extended runway centerline.

The Radar Controller offered the option to the flight crew to descend to 500 meters QFE, which the Commander accepted.

The Investigation believes that it is most likely that the flight crew became concerned and discussed the position of the Aircraft between the time when the second ILS clearance was given (1750:12) by the Radar Controller and the time when the Commander requested to descend to 500 meters QFE at 1751:36.

The altitude was then set to 2,300 feet after the descent request. However, the Commander did not discuss the Radar Controller's offer with the Co-pilot, since the Commander directly replied to the Radar Controller. The Co-pilot selected the altitude to 2,300 feet (about 500 meters QFE) without discussion, which indicated that he agreed with the Commander's decision to descend.

The Co-pilot had about 55 seconds to consider his concern, if any, before selecting the airspeed to 170 knots after engaging 'speed managed' mode. The 55-second was the period between the time when the Co-pilot set the altitude from 3,330 to 2,300 feet (at 1751:38) and the time when he selected back the airspeed to 170 knots. During this time, the following tasks for the approach occurred in sequence:

- The Radar Controller communicated and affirmed the clearance to descend the Aircraft to 500 meters. The Controller repeated the clearance for the runway 14R ILS approach and repeated the heading change to 220 degrees. The Controller also provided a new instruction to maintain 170 knots as long as possible due to traffic behind the Aircraft. No reply was provided by EK131;
- The landing gear lever was set to the down position;
- The ground spoiler was set to armed;
- The Radar Controller contacted the flight crew and informed them that the separation with the other aircraft was good, and offered no speed limit. This was replied correctly by the Commander;
- FMS sequencing;
- As the Commander read back about 'no speed limit' to the Radar Controller, the selected heading was changed from 220 to 212 degrees, which was carried out by the Co-pilot;
- The flaps lever position was set from configuration '2' to '3';

- The Commander requested the Co-pilot to set ‘speed managed’ mode. This was actioned by the Co-pilot;

Referring to what was taking place during the 55-second period as listed above, the Investigation believes that the Co-pilot mainly focused on the Aircraft configuration for the approach and landing at this time. The 55-second period should have been minimal for the number of occurred tasks, therefore, the Investigation believes that this available time was not sufficient to complete the required tasks. In addition, his mental picture of the situation was that the Aircraft was high as he only referred to the glide deviation indication.

The Co-pilot might have observed the pressure altitude or navigation and vertical display, but because of the high workload at this time, he referred to the glideslope deviation indication to obtain direct information on the vertical position of the Aircraft in relation to the ILS glideslope. The pressure altitude indication could have required a longer mental processing time to obtain the actual Aircraft vertical position since the Radar Controller used meters instead of feet.

Had both pilots appropriately assessed the high position of the Aircraft before it reached a position abeam the AMTAM waypoint, the outcome might have been different.

The Investigation believes that when the Radar Controller offered the flight crew free airspeed, it was the last opportunity for the flight crew to assess the Aircraft vertical position and to plan on how to manoeuver the Aircraft to establish on the localizer and intercepting the glideslope. At this point, the Aircraft was on a base leg about 4.2 nautical miles from the extended runway centerline (final approach leg) and the flight crew may have expected to establish the Aircraft on the localizer in about one minute and 36 seconds, if the airspeed was maintained at 170 knots with a groundspeed of approximately 158 knots.

Had the flight crew performed an assessment of the horizontal and vertical position of the Aircraft together before the option of free airspeed was given, they might have prepared a plan to fly and manage the Aircraft for the ILS 14R approach, which would have more benefits for the flight crew in timing and handling the workloads. The assessment should have included the ILS glideslope signal coverage.

In addition, the Investigation believes that had the flight crew accurately assessed the Aircraft position, the Co-pilot might not have changed the heading from 220 to 212 degrees, reset the speed managed mode to selected mode at 170 knots, and performed the *glide interception from above* procedure. The Co-pilot set the heading from 220 to 212 degrees to shallow the approach angle to final course with his assumption that the localizer should have almost been intercepted.

2.2.10 Flight crew shared mental model

The Radar Controller provided clearance for the ILS approach three times. The Investigation believes that when the Aircraft was still far from the localizer course (before the second ILS clearance was given), the flight crew, most probably, practiced the basic distance versus altitude crosscheck in order to anticipate the Aircraft vertical position with respect to the glide on intercepting the localizer course. Their initial focus was the high angle of interception and the Aircraft energy, which could have led to a possible overshoot of the localizer. The interview with the Commander indicated that when the Aircraft was on the base leg about 9.7 nautical miles from the interception course (final approach leg), ATC provided ILS clearance. This was the second clearance. The Commander then became concerned that the Aircraft would intercept the localizer inside the FAP. The Commander then discussed with the Co-pilot about the possibility of becoming high on profile and intercepting the glideslope from above, which the Co-pilot then agreed.

Up until this stage of flight, the Investigation believes that a shared mental model existed as the flight crew had discussed the possibility of becoming high on profile.

Due to his concern of 'becoming high on profile', the Commander's focus, probably, shifted towards the management of the vertical profile. Hence, the Commander requested to descend to 500 meters QFE and to establish at that level, and in fact, the Controller had offered the descent previously. The Radar Controller approved the Commander's request, and at the same time provided the third ILS clearance. Therefore, this condition naturally made the basic distance versus altitude crosscheck a secondary priority since both conditions could not occur simultaneously (high and low on profile) for the Commander.

The Co-pilot set the selected altitude from 3,300 feet to 2,300 feet, however, he, probably, was not aware about the intention of the Commander's to descend the Aircraft to 500 meters QFE. The Investigation believes that their shared mental model of 'becoming high on profile' started to diverge when the Commander suggested to request a descent to 500 meters QFE, as a prevention strategy to avoid being high on profile. This, probably, happened since the Commander did not verbalize or explain to the Co-pilot the intent of his suggestion, which was to prevent the Aircraft becoming high on profile.

As the Aircraft was descending through 3,000 feet pressure altitude from 3,300 feet to 2,300 feet QNH, the Radar Controller offered 'no speed limit'. The Commander then changed his focus back to energy management and the localizer intercept angle as the vertical profile management was no longer a concern. The Commander did not verbalize again his change of focus. The consequence of the Commander not clearly verbalizing the update of his mental model, probably, resulted in the Co-pilot's expectation bias of the Aircraft becoming high on profile. Therefore, the Co-pilot maintained his focus to remain on the recovery strategy of intercepting the glideslope from above.

The Co-pilot's initial expectation that the Aircraft would be high on profile was aligned with reality and consistent with the shared mental model discussed with the Commander. However, after the Radar Controller cleared EK131 to descend to 500 meters QFE, the Co-pilot failed to recognize that this would place the Aircraft on the desired vertical profile of 2,300 feet pressure altitude. Instead, he proceeded to apply the 'glide interception from above' procedure, which indicated that he had lost his situational awareness of the actual Aircraft position relative to the desired descent profile.

It is likely that the Co-pilot did not recognize that the actual aircraft position was below the profile due to confirmation bias[23], which resulted in testing his beliefs or hypothesis in a one-sided way by only searching for evidence or information that supported his belief. Rather than searching or checking all the available information, which might have challenged his belief, the Co-pilot may only have considered a single piece of information that confirmed his belief or expectation.

The Co-pilot stated that as the Aircraft approached 2,300 feet pressure altitude as the cleared altitude, he observed that the glideslope deviation indication on the PFD still showed the Aircraft being above the glideslope. He then decided to apply the *glide interception from above* procedure, since he only focused on the glideslope deviation indication and he was concerned about being high on the profile.

It is most likely that the Co-pilot erroneously focused on the glideslope indication, as it supported his mental model and confirmed his expectation that the Aircraft was high on profile. Even when the Aircraft had actually descended below the profile, the Co-pilot continued to focus on the glideslope indication at the expense of other indications, which would have challenged his belief that the Aircraft was high on profile.

The Co-pilot did not communicate his intentions to the Commander and did not ask for an ATC clearance for further descent. Should the Co-pilot have shared his assessment and intended actions with the Commander, it could have prevented his false perception of the Aircraft vertical height.

[23] Confirmation bias is defined as a tendency to favor information that confirms one's beliefs or hypothesis.

Even though the Commander should have been able to independently monitor the approach using other valid information, it was apparent that the crew did not have a shared mental model as to how the approach would be flown. The absence of a shared mental model increased the risk that the Commander would not have anticipated and responded appropriately to the Co-pilot's actions.

It is also possible that the general limitations of human monitoring capability, as discussed in sub-section 1.18.3, could have influenced the Commander's performance, such that his monitoring ability became diminished.

2.2.11 Air Traffic Control

Based on the ATC recording provided to the Investigation, the Controller was busy managing many aircraft. In general, the traffic management was normal, with communication in the Russian language with the other flights.

The Investigation believes that the Radar Controller's instruction to take up a heading of 220 degrees, and to offer a descent to 500 meters and free airspeed, gave the opportunity to the flight crew to choose any options in establishing the Aircraft on the localizer. The flight crew could have flown the Aircraft between 800 and 500 meters, until reaching the extended runway centerline.

The Controller was assertive when he provided the instruction to terminate the descent. The Controller had not expected that the Aircraft was descending below 500 meters, and he then reacted by providing a 17-second long and non-standard instruction to terminate the descent. The Investigation believes that the unexpected descent below 500 meters caused a disruption in the Controller's instruction to halt the descent and this resulted in a long and non-standard instruction.

Despite the relative long instruction to terminate the descent by Radar Controller, however, this instruction was still an additional safety defense since it occurred before the activation of the enhanced ground proximity warning system (EGPWS), and the terrain awareness and warning system (TAWS). The activation of EGPWS and TAWS would have been the final safety defense if both flight crew were still not aware of the Aircraft's valid vertical position after the Controller's instruction to halt the descent.

In general, the Controller's communications in English were understandable, including the descent termination instruction. However, in such a situation, when the Aircraft was descending below its cleared altitude of 500 meters, it would have been appropriate to transmit a shorter instruction and only passed standard necessary message(s), so that the flight crew would have had more time to react and to perform the recovery earlier.

Therefore, the Investigation recommends that Domodedovo ATC management emphasize to the Controllers to use only standard communication terminology, especially in urgent situations.

According to ICAO Doc 4444, Procedures for Air Navigation Services – Air Traffic Management, sub-section 8.9.3.6, it is mentioned that Aircraft vectored for final approach should be given a heading or a series of headings calculated to close with the final approach track. The final vector shall enable the aircraft to be established on the final approach track prior to intercepting the specified or nominal glide path of the approach procedure from below, and should provide an intercept angle with the final approach track of 45 degrees or less.

When the Aircraft was on the base leg, the Radar Controller provided a series of headings, one of which was a heading of 220 degrees when the Aircraft was approximately 11.8 nautical miles from the final approach track. However, the Co-pilot changed this heading to 212 degrees when the Aircraft was approximately 4.2 nautical miles from the final approach track without Controller instruction or a request from the flight crew.

The flight crew may have anticipated that the Controller would provide the next heading instruction later as the Aircraft neared the final approach track. However, when the Aircraft was approximately 2.6 nautical miles from the final approach track, the Radar Controller instructed the flight crew to maintain the current heading, which he believed to be 220 degrees, and to contact Tower control.

Instructing the flight crew to contact Tower control, indicates that the Radar Controller did not provide a proper last vector (heading instruction) that might have resulted in an 85-degree localizer intercept angle. In this case, the Controller left it to the flight crew to choose the point of the required heading change to establish the Aircraft on the localizer and intercept the glide path, which was not in accordance with the procedure in ICAO Doc 4444 sub-section 8.9.3.6. However, as discussed in sub-section 2.2.8, the Aircraft would have captured the glideslope from below, but only if 500 meters QFE (2,300 feet QNH) had been maintained and the *glide interception from above* procedure had not been carried out.

Following the Controller's instruction to maintain the current heading and to contact Tower control, there was no reply from the flight crew, and because the Aircraft was descending below 500 m QFE, the Radar Controller instructed the flight crew to terminate the descent, and the flight crew then performed a go-around.

During the second and third approaches, the last vector (point of required heading change) was provided, which complied with the procedure of ICAO Doc 4444 sub-section 8.9.3.6. The last vector instructions on the second and third approaches were provided by Radar Control and not by the Tower control.

The fact that the Radar Controller did not provide the flight crew with a proper last vector to establish on the ILS during the first approach, was not a contributing factor in the continuous descent below 500 meters QFE. This is believed to be the case since the Co-pilot changed the heading from 220 degrees to 212 degrees without ATC instruction or a request from the flight crew prior to the Radar Controller instruction to contact Tower control, and the Aircraft descent was already below 500 meters QFE.

However, during the approach briefing prior to the descent from FL380 (top of descent), the Co-pilot had already expected that Radar Control might not provide them with vectors to intercept the localizer when the Aircraft would be on the base leg at 90-degrees to the final approach track. With this expectation, and additionally, the provided radar vectors inside the FAP including maintaining high speeds until the Aircraft was almost abeam with IAF point as instructed, resulted in an unusually high workload in this dynamic approach phase. This led to degradation of the flight crew situational awareness, a breakdown in the teamwork as their shared mental model diverged, and ultimately to an inappropriate decision of performing the glide intercept from above procedure and using improper indication when performed it. Therefore, the Investigation considers that this unusual high workload condition was a contributing factor of the descent below the cleared altitude of 500 meters QFE.

Based on the fact that the Radar Controller did not comply with ICAO Doc 4444 sub-section 8.9.3.6 for the intercept angle of the first approach, the Investigation recommends that UUDD ATC ensure the implementation of the related procedure.

2.2.12 The design of *glide interception from above* procedure

During the course of the Investigation, a question was raised of what if a setting of a lower altitude is introduced, as an additional barrier to reduce the risk of controlled flight into terrain (CFIT), instead of setting a higher altitude as a prerequisite of the *glide interception from above* procedure.

After the review and discussion with the Aircraft manufacturer, the feasibility of an additional barrier consisting in the selection of an FCU altitude below the current aircraft

altitude as a prerequisite for applying the *glide interception from above* procedure is described below.

Several barriers existed to reduce the risk of CFIT at aircraft systems and operational levels. In this case, some barriers have been breached: inappropriate application of the *glide interception from above* procedure; inappropriate monitoring of the glide capture; disrespect of the last cleared altitude given by the Radar Control; and disrespect of the approach stabilization criteria (gate) at 1,000 feet above aerodrome level (AAL) as per the *OM-A*.

Other barriers, as the call out by Radar Controller and triggering of the TAWS warnings, have worked.

All of these barriers delivered alerts to the flight crew whatever the current situational awareness of the flight crew was.

If setting an appropriate FCU altitude below the aircraft altitude is made and a go-around is then required, during the dynamic phase of a go-around, an omission to set the FCU altitude above the current aircraft altitude can lead to a situation of level bust in a terminal area,

Setting an appropriate FCU altitude below the current aircraft altitude, by taking into account the aerodrome topography and the published minimum safe altitude necessitates the flight crew to have a correct situational awareness and anticipation.

As highlighted previously, the flight crew degraded situational awareness was most probably the reason why the procedure glide capture from above was inappropriately applied. The lack of anticipation/strategy was most probably the reason why the Co-pilot improvised and unannounced the application of procedure that resulted in preventing momentarily any support from PM.

The risk to perform a go-around becomes higher when the FCU lower altitude selection is made higher (closer to the current aircraft altitude). There is a greater chance for altitude capture engagement to occur before the glide capture, leading the flight crew to trigger a go around should the approach stabilisation criteria cannot be recovered before 1,000 feet AAL in IMC or 500 feet AAL in VMC as per *FCOM*. A performed go-around that is very close or below the FCU altitude can trigger a fast sequencing of the go-around mode followed by altitude capture mode that lead to an undesired aircraft state, if the change of guidance mode on FMA lately noticed by the flight crew.

During the dynamic phase of a go-around, using the FCU altitude knob to set the go-around altitude by a “pull and turn” technique instead of the recommended “turn and pull” technique, may result into a reversion to vertical speed mode with a vertical speed target synchronized on the current aircraft vertical speed, which is not yet positive, if a change of guidance mode and target lately noticed by the flight crew.

Therefore, introducing an additional barrier consisting in the selection of an FCU altitude below the current aircraft altitude may be considered against the risk of ground impact, however, it is not drawback free, considering the flight crew having a degraded loss of situational awareness. As mentioned, it can increase risk of un-stabilized approach or go-around management with additional tasks to configure the aircraft correctly.

Setting a target altitude below the current altitude requires a minimum situational awareness to keep the right representation of the aircraft position, vertically and laterally, with respect to the runway threshold and approach path. A “one for all” value of FCU altitude could not be defined and recommended to fit all situation that can be encountered when approaching on different airports and different procedures. Hence, the Investigation considers that setting a target altitude above the current altitude when performing the *glide interception from above* procedure is appropriate as given in the *FCOM* SOP.

2.3 FMS reset on Second Approach, Oscillation along the Localizer Axis, and Discontinued Approach

2.3.1 The second approach

Following the go-around from the first approach, the flight crew attempted a second approach to runway 14R. The Commander requested radar vectors for the approach with a longer final leg in order to have more space during the approach leg (from the initial approach until the final approach leg). The Radar Controller provided lateral vectoring via the AMTAM waypoint for the second approach, which resulted in a longer final leg compared to the first approach. The Controller could not provide a longer final leg since there was a prohibited area P53 to the north-west of UUDD.

After the go-around, when the Aircraft was about six nautical miles from the extended runway centerline at 1756:46, the approach phase was activated in the FMS by selecting and confirming the 'ACTIVATE APPR' (in amber), which was displayed on the MFD 'performance' page. The Aircraft was maintaining level at 3,600 feet QNH and 200 knots airspeed, in a slats/flaps clean configuration on a 180-degree heading.

Autopilot 1 (AP1), both flight directors, and autothrust were engaged in 'altitude hold' / 'heading' / 'speed' modes. Twenty four seconds later, the heading was selected to 140 degrees and the Aircraft started to turn to the left.

When the Aircraft was about 7.5 nautical miles from the extended runway centerline (crosstrack position), at 1757:27, a lateral revision of the flight plan was carried out from the Commander's side, by inserting an II14R (IF/intermediate fix) waypoint using the DIR TO CRS IN function. Therefore, the previous active INTCPT waypoint was replaced by the II14R waypoint as the current active waypoint. The Commander's intention was to revise the flight plan by selecting II14R waypoint as the new waypoint to bring the Aircraft to the beginning of the runway 14R ILS straight in approach segment.

Five waypoints, including the runway 14R ILS approach waypoints and the destination runway (II14R, DD142, UUDD14R, 990 and INTCPT) of the active flight plan were sequenced in a row by the FMS, started at 1759:37, and this was followed by an automatic reset on FMS1 (FMS on Commander side). The FMS1 single auto-reset was also recorded on the post flight report (PFR), as shown in Appendix 4 to this Report.

The multi-waypoint sequencing was the result of a logic included in the FMS to enable sequencing waypoint(s) of the flight plan when it was not strictly followed by the Aircraft due to radar vectoring.

The logic to sequence an approach waypoint in this case, when the heading mode was engaged, as the following:

- Aircraft position is behind the sequencing plan;
- Crosstrack (XTK)[24] is less than 7 nautical miles;
- Track angle error (TKE) is less than, or equal to 90 degrees.

Figure 35 illustrates how the logic was triggered, which led to the multi-waypoint sequencing.

[24] Crosstrack (XTK) = distance to extended runway 14R centreline (Runway 14R centerline axis)

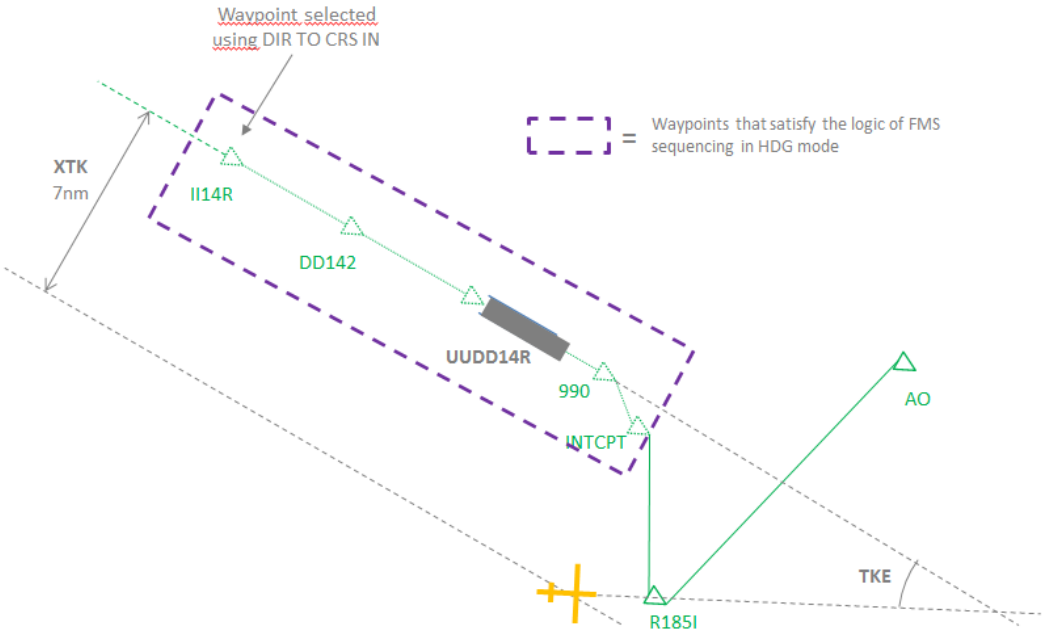


Figure 35. Illustration of the logic of waypoints sequencing

Inserting the II14R waypoint by using the DIR TO CRS IN function, was carried out when the Aircraft crosstrack (XTK) position was greater than seven nautical miles. Two minutes and 10 seconds later, and when the XTK was less than seven nautical miles, the multi-waypoint sequencing occurred (figure 35).

The multi-waypoint sequencing in a row occurred to fulfill the geometric conditions used to sequence a waypoint (geometrical waypoint sequencing rules) when the Aircraft flew close to the flight plan (F-PLN) route computed by the FMS, following the vectoring provided by the Radar Controller.

Based on the manufacturer and the FMS supplier reports, the FMS1 reset was a consequence of multi-waypoint sequencing in a row in the flight management software. FMS1 performed consecutively a single auto-reset due to a real time computation issue and led to transiently losing the display of the flight plan only on the Commander's side.

Consecutively to the multi-waypoint sequencing by the FMS, the FMS2 (FMC-B) and backup on standby (FMC-C) remained in its normal state during the FMS1 auto-reset. During this period, 'MAP NOT AVAIL' (in red), and 'FMS PAGE NOT AVAIL' (in amber) messages were displayed on the ND and MFD, respectively, on the Commander's side only. The flight plan was not lost and was still displayed on the Co-pilot's ND and MFD. Nominal dual FMS operation was fully recovered approximately 32 seconds after the single FMS1 auto-reset.

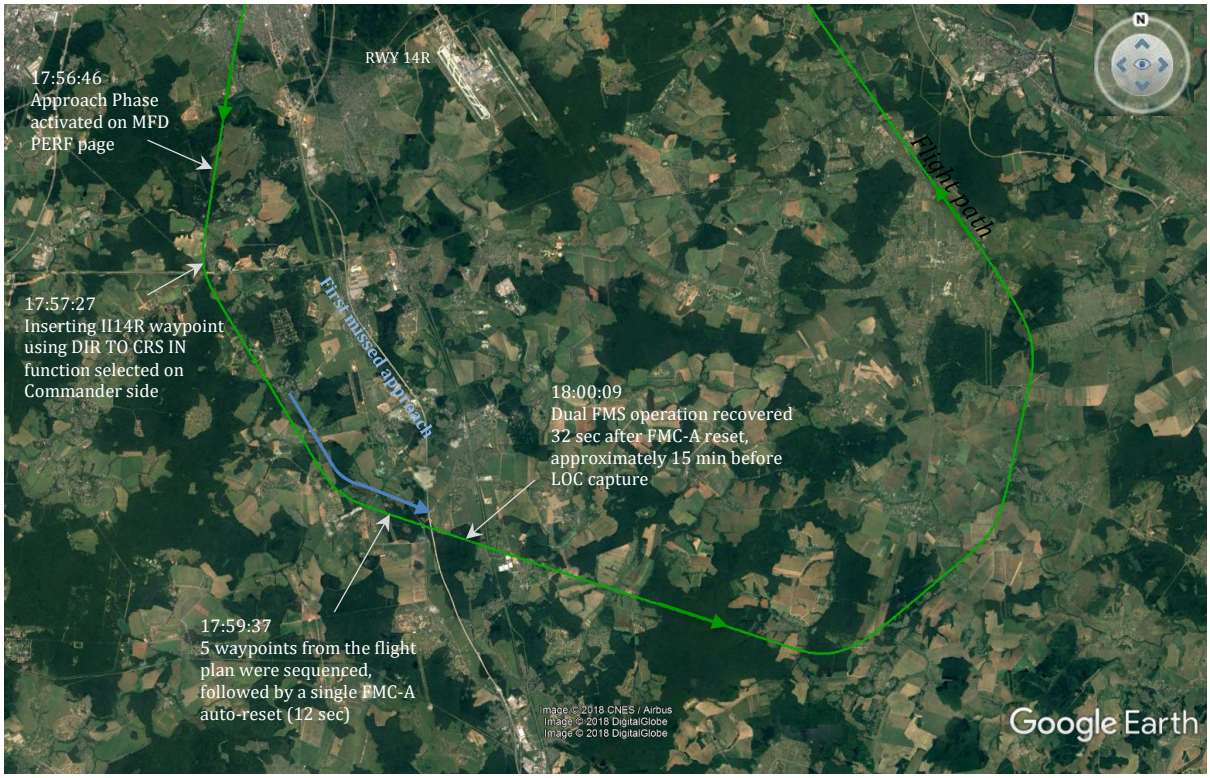


Figure 36. Aircraft trajectory after the go-around and preparation for the second approach

The lateral vectoring provided for the approach was almost the same track as the published instrument approach chart for the runway 14R ILS via the AMTAM waypoint (figure 5).

The flight crew did not take action to reconfigure the FMS for the second approach by re-inserting the runway 14R ILS approach. Reconfiguration of the FMS by inserting the runway 14R ILS approach (adjusting the sequencing of the flight plan) was required before the localizer capture, in order to obtain the correct position of the destination runway.

Between the time when the dual FMS mode operation was recovered and when the Aircraft captured the localizer (about 15 minutes), there was no evidence on the FMS BITE data that the FMS had been reconfigured by adjusting the sequencing of the flight plan as per SOP.

During this period, there were many radio communications between the Radar Controller and the Commander. The communications were mainly about the approaching vector. When the Aircraft was on the downwind leg, about two nautical miles before turning onto the base leg, the Commander queried whether the Aircraft could maintain heading for some additional nautical miles. The Commander's request was not approved since there was a prohibited area about four kilometers ahead of the Aircraft. The event of Aircraft being low on the first approach and the subsequent go-around, caused the Radar Controller to become concerned about the Aircraft, and hence, the Radar Controller gave more attention to the flight crew's intentions during the second approach. During this period, the AO (Aksinyino NDB, figure A2.1) waypoint was the active one in the flight plan.

The Commander stated that he looked at his MFD and ND when the Aircraft was on the downwind leg, and he found that the flight plan was not displayed. However, he did not know precisely when or where the disappearance of the flight plan had occurred.

When the Aircraft had completed the left turn from the downwind onto the base leg and while maintaining 3,300 feet pressure altitude (just above 800 meters QFE) with a constant airspeed of 180 knots, the Commander asked the Co-pilot whether the Approach

mode could be armed, which was agreed by the Co-pilot. Therefore, the Co-pilot pressed the APPR pushbutton and the glideslope mode and LOC mode became armed as displayed on the FMA.

Just after the APPR pushbutton was pressed, the Co-pilot pressed the AP2 pushbutton, which resulted in engagement of both autopilots, since AP1 was already engaged.

Very shortly, after the Aircraft entered the base leg, the Commander became concerned about the Aircraft altitude, such that he thought that the Aircraft needed to descend. Therefore, he informed Radar control and requested a lower altitude. However, the Radar Controller instructed EK131 to maintain the Aircraft at 800 meters QFE, as per the procedure. There followed several communications between the Radar Controller and the Commander to convince the Commander that by maintaining 3,300 feet pressure altitude, as the Aircraft was, it would lead the Aircraft onto the final approach leg as per the runway 14R ILS chart without any problem. This means that the Aircraft was positioned to establish the runway 14R ILS without any issue. These communications took place over one minute within which the following events occurred sequentially:

- The SPD knob was pushed which engaged speed managed mode, since the Radar Controller had provided speed at flight crew discretion. However, the Investigation could not determine who pressed the SPD knob;
- The flap lever position was set to configuration ‘2’
- The heading was changed from 210 to 220 degrees, as instructed by Radar control.
- The landing gear lever was set to the ‘down’ position; and
- The flap lever position was set to configuration ‘3’.

At the end of this one-minute communication, the Commander acknowledged the instruction. At this time, the Aircraft was passing the AMTAM waypoint.

The Radar Controller contacted the flight crew and repeated the clearance to establish on the runway 14R ILS at heading 220 degrees and the offer of no speed limit. The Radar Controller also informed EK131 that one aircraft was on the final approach leg at a distance of 10 kilometers ahead of EK131. Thereafter, the flap lever was set to ‘full’.

When the Aircraft was on the base leg about two nautical miles from the extended runway centerline, the Radar Controller contacted EK131 and asked whether the flight crew were ready to make a left turn to establish on the localizer. The Commander replied and informed the Radar Controller that they were ready. After the Commander’s read back, the Radar Controller instructed EK131 to turn left to establish on the localizer, and to contact Tower Control on 118.6 MHz.

During the Radar Controller’s call, the Aircraft heading was selected to 190 degrees for a left turn. At this time, the Aircraft was approximately 1.6 nautical miles from the extended runway centerline axis.

When the Aircraft was turning left, and about 0.5 nautical miles from the extended runway centerline, the LOC pushbutton was pressed, the glideslope mode became disarmed, and autopilot 2 became disengaged. It is most likely that the Co-pilot pressed the button. He then set the heading to 180 degrees. It was not clear to the Investigation why the LOC pushbutton was pressed since the localizer and glideslope modes were already armed.

The Co-pilot then, most probably, looked at the FMA and noticed that the glideslope mode was not armed and that AP2 was not engaged. Therefore, he pressed the APPR button to arm the glideslope mode and pressed the AP2 button to engage AP2.

In the meantime, the Commander contacted Tower Control. The Tower Controller replied and instructed EK131 to continue the approach.

The Commander then looked at his MFD and ND during the left turn from the base leg onto the final approach leg, and it revealed that the flight plan was not displayed on his MFD. The Co-pilot also noticed the blank flight plan on the FMS.

After the multi-waypoint sequencing of the flight plan occurred, there was no evidence that both flight crew were aware that reconfiguration of the FMS by inserting the runway 14R ILS approach was required before the LOC (localizer) capture.

The Investigation believes that both flight crewmembers were suffering from stress following the go-around, and that they focused more on the vectoring of the second approach provided by the Radar Controller and on setting the Aircraft configuration for the second approach and landing when the Aircraft was on the base leg. This caused them to forget to carry out the required FMS reconfiguration for the approach.

Alternatively, both flight crewmembers, possibly, considered that re-inserting the runway 14R ILS approach in the flight plan was not required after the multi-waypoint sequencing, since they had already carried this out before. This also could be a reason why the flight crew did not reconfigure the flight plan by re-inserting the ILS 14R approach.

The AO waypoint was active after the multi-waypoint sequencing and remained so for about 16.5 minutes. Had the flight crew noticed that the AO waypoint was the active one on the flight plan, they might have recognized that re-inserting the ILS 14R approach would be required before the Aircraft captured the localizer.

2.3.2 Localizer capture overshoot and oscillations

On turning onto the final approach leg, before reaching the IF waypoint at approximately 10.2 nautical miles (displayed on both NDs) from the runway 14R threshold, the Aircraft state was:

- Both autopilots, flight directors, and autothrust were engaged in ‘altitude hold’ / ‘heading’ / ‘speed’ modes;
- Glideslope mode had been armed by pressing the approach pushbutton, while localizer mode was already armed;
- Speed managed mode was used with an airspeed target of 138 knots;
- The flap lever was at ‘full’ (slats/flaps were at 23/32 degrees);
- Both QNH settings were already set at 1015 mbar;
- The Decision Altitude had been set to 800 feet;
- The active waypoint was the AO waypoint;
- The LS pushbuttons were ON or in activation condition on the Commander and Co-pilot sides, meaning that the localizer and glideslope deviations appeared on the PFD when signals were available; and
- LS1 and LS2 frequencies were 110.10 MHz.

The localizer capture mode became engaged when the displayed LOC (localizer) deviation indication showed 0.8 dot left side from the localizer axis while decreasing, at 1815:09. The Aircraft was approximately 9.5 nautical miles from the runway 14R threshold. The localizer interception angle was 42 degrees. The headwind component was 9 knots, and the crosswind component was 6 knots from the right side (based on the Aircraft true heading).

The localizer capture mode was engaged by the AFS, in line with the design logic. In particular, when the pre-LOC capture was not available, the engagement of basic LOC capture was expected to occur when the localizer deviation should have reached +174 µA (as designed), and in this case it occurred at +63 µA (0.8 dot). The roll order should have been such that the capture of the LOC axis should have been performed with a single turn, which was not the case in this event. The maximum display of the localizer deviation indication was two dots left and right.

The engagement of the localizer capture mode would have been expected to occur within the time from when the Aircraft was turning left from the base leg onto the final approach leg, which was not the case in this event. During the left turn the Aircraft came back to wings-level prior to reaching the IF waypoint, and then the engagement of the localizer capture occurred.

The first localizer overshoot occurred when the localizer deviation indication was at 1.3 dots on right side of the localizer axis and the maximum left bank angle reached was 27 degrees.

The glide slope capture mode became engaged, about 14 seconds after the engagement of the localizer capture mode, when the Aircraft was on the first oscillation of the localizer overshoot and passing (near) the IF waypoint.

The glide slope track mode became engaged when the Aircraft was still on the first oscillation of localizer overshoot before reaching the P as the final approach point, while the localizer capture mode remained engaged. However, the localizer track mode never engaged on the approach.

Thereafter, two oscillations followed with an overshoot of 0.65 dot with the Aircraft on the left side of LOC axis, and then 0.7 dot on the right side of the localizer axis.

The maximum bank angle of the second and the third LOC overshoots reached 16 degrees right bank and 16 degrees left bank respectively. However, despite the large bank angles commanded by the AFS, the localizer overshoot was not significantly out of phase with the localizer deviation indication (1.3 dot on the right side of the localizer axis for the first LOC overshoot).

When the Aircraft was on the final approach leg, near the IF waypoint and a distance of about 9.1 nautical miles from the runway 14R threshold, the glide slope capture mode became engaged. The Aircraft started to descend to 3,220 feet QNH (800 meters QFE) from the selected altitude of 3,300 feet, then, the selected altitude was set to 2,600 feet (about 600 meters QFE), as the missed approach altitude. When the Aircraft had almost reached the P and a distance of 8.4 nautical miles from the runway 14R threshold, the glide slope track mode became engaged.

With the Aircraft at a distance of 6.5 nautical miles from the runway 14R threshold, at 1816:31, the UUDD14R waypoint was selected by the Commander using the DIR TO function in the FMS. This action resulted in disengagement of the localizer capture and glide slope track modes, engagement of the altitude hold and navigation modes, and disengagement of autopilot 2 (AP2). Hence, the approach was discontinued at 2,612 feet pressure altitude. The Aircraft stopped descending on the glideslope, and since the Aircraft was at 2,612 feet (a 12 feet difference from the 2,600 feet selected altitude), the engagement of the altitude hold mode occurred, instead of the altitude capture mode.

The fact that the runway 14R ILS approach flight plan was not displayed in the FMS, the engagement of the localizer capture mode and the glide slope track mode, and the three-localizer oscillations, surprised the flight crew, as they had not expected these events to happen.

The Commander stated that he checked his PFD and it showed the ILS of the IDM frequency (110.10 MHz). Although the glide slope track mode was engaged and it revealed the glideslope deviation showed a proper indication (figure 37), the Commander was not comfortable with the situation and the Aircraft state due to the FMS issue (blank flight plan) and the localizer oscillations. This, most likely, was the reason that in his perception he needed to direct the Aircraft to the runway using the FMS, after he expressed his concern to the Co-pilot about the FMS issue. With the insertion of the runway waypoint (UUDD14R), the Commander aimed to provide FMS position data displayed on the ND. Therefore, he selected the UUDD14R waypoint using the DIR TO function in the FMS. However, his action resulted in the Aircraft leveling off at 2,600 feet QNH. The Commander had not announced his intention to the Co-pilot before he used the DIR TO function.

Until the selection of the UUDD14R waypoint using the DIR TO function, the Aircraft followed the glideslope, as shown in figure 37, the glideslope deviation indication showed approximately on the profile.

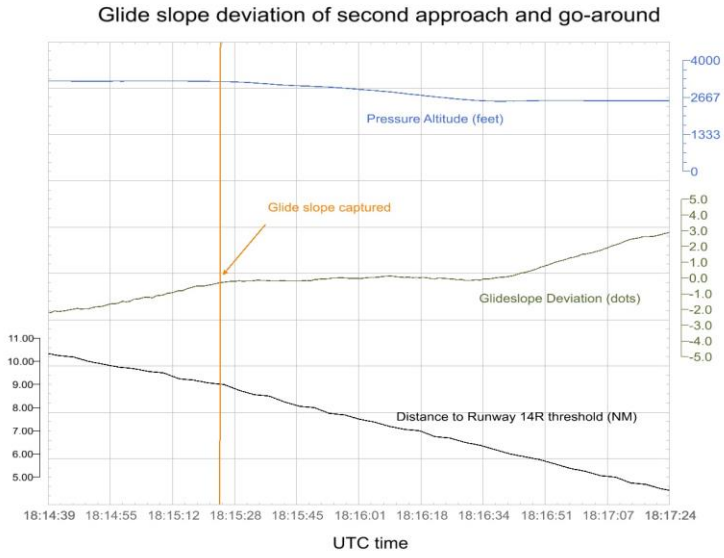


Figure 37. Glideslope deviation for the second approach and discontinued approach

The Co-pilot stated that he looked outside and saw the two white and two red lights on the PAPI when the Aircraft was laterally oscillating before the DIR TO function was used. Then, when his view was back into the cockpit, he saw on the FMA that the altitude hold and navigation mode had become engaged.

The Commander did not realize what was happening. He stated that he asked the Co-pilot “What happened?” and at the same time, he looked outside and saw the two white and two red lights on the PAPI, meaning that the Aircraft was on the glideslope. The Co-pilot then replied, “It went to NAV”, followed by an exchange of comments between him and the Commander. At the end of the discussion, the Co-pilot mentioned that the Aircraft was already high on the glideslope, and he proposed that they carry out a new approach, meaning to fly a discontinued approach. The Commander agreed and declared the go-around to the Tower Controller. The discussion between the flight crewmembers took about 26 seconds from when the Commander applied the DIR TO function until he informed the Tower Controller of the intended go-around.

When the discontinued approach was initiated, the Aircraft deviation showed 1.3 dots, about 200 feet above the glideslope profile based on the runway 14 R ILS chart (about 300 feet above the theoretical 3 degrees glideslope). The Aircraft was approximately 5.4 nautical miles from the threshold. Since the Aircraft was at the selected altitude (missed

approach altitude) of 2,600 feet, during the discontinued approach, the Aircraft maintained the same altitude level. Therefore, TOGA thrust was not activated and the thrust levers were left in the CL detent for the discontinued approach.

In addition to the first go-around experience, the Investigation believes that the relatively high workload during the approach and the FMS and localizer oscillations issues increased the Commander's stress level. His stress level may have reached a point that led to anxiety and a reduction in his performance, which affected his judgement, attention, memory and concentration. Consequently, he overlooked informing the Co-pilot of his next action plan in using the DIR TO function.

The Commander was not aware of the consequences of his use of the DIR TO function, since he later asked the Co-pilot what had happened.

His intention in using the DIR TO function was to direct the Aircraft to the runway 14R threshold (UUDD14R waypoint) and aimed to provide FMS position data displayed on the ND. Using the DIR TO function was an impulsive action since the runway 14R ILS approach flight plan did not appear in the FMS and the Aircraft was already on the glideslope. The Commander's action was not sufficiently thought through as to the consequences, and this was most likely due to his relatively high stress level at that time.

Had the Commander informed the Co-pilot prior to using the DIR TO function, there would have been a possibility that the Co-pilot could have continued the approach and landed the Aircraft by manually flying the ILS since the Aircraft was already established on the glideslope and visibility was not an issue.

The decision by the flight crew to discontinue the second approach was correct and safe since the Aircraft was already above the profile.

As mentioned in the manufacturer's report, an engineering simulator session was performed with real PRIM and FMS computers that held the pre-LOC capture function and LOC capture control law. The first discontinued approach and the oscillation of the Aircraft trajectory along the LOC axis were successfully reproduced (simulated) using a particular test means to trigger an FMS1 auto-reset. The discontinued approach was replayed several times without triggering the FMS1 auto-reset after the multi-waypoint sequencing. A particular test mean was used to force an FMS1 reset as per the actual event.

From the simulation, the root cause of the oscillations has been identified:

- The multi-waypoint sequencing of the flight plan (including the destination runway, UUDD14R), combined with the FMS auto-reset on the Commander's side led the FMS to send erroneous data to the LOC capture control law performed by the Flight Guidance and Control computer (PRIM). The estimators of the relative Aircraft position to the LOC axis, computed by the LOC capture control law, were incorrectly initialized following the FMS1 auto-reset, using erroneous data sent by the FMS. The erroneous data sent by the FMS were derived from the destination runway position set to the default value (latitude 0, longitude 0), after being sequenced and followed by a software auto-reset.
- Re-inserting the approach into the flight plan after the FMS1 auto-reset enables the updating of the destination runway with the correct position. Thus, the capture control law can initialize correctly the estimators of the relative aircraft position to the LOC axis that are necessary to ensure good performance of the control law. During the attempted second approach, the FMS was not reconfigured by inserting the ILS 14R approach.

Based on these findings, two solutions are under review by the Aircraft manufacturer:

- For the design aspect: the fix definition and implementation will be discussed with the supplier (FMS manufacturer) for implementation at the opportunity of the next FMS standard.
- For the operational aspect:
  - System description and procedures are under review taking into account that a nominal situation will be recovered if the FMS is reconfigured to perform the approach after a single FMS auto-reset.
  - Guidance enhancement for efficient use of the DIR TO CRS IN function during approach and missed approach phases to avoid multi-waypoint sequencing.
  - Describe the FMS waypoint sequencing rule that can potentially lead to multi-waypoint sequencing.

For the initial approach phase, the *FCOM* and *FCTM* provided the standard operating procedures for the flight plan sequencing.

For leaving the go-around phase, only the *FCTM* explained how to obtain the proper target speeds and proper predictions depending on the strategy chosen by the pilot. The two strategies that could be selected were either to fly a second approach, or divert to another airport. If it was decided to fly another approach, the pilot could activate the approach phase by selecting and confirming the 'ACTIVATE APPR' displayed on the MFD PERF page. By doing so, the pilot ensures correct waypoint sequencing during the next approach in order to have the missed approach route available, should another missed approach or go-around be required. If another go-around is not required, activation of the approach phase only affects the target speeds and does not affect waypoint sequencing. However, activating the approach phase is not necessary as long as the proper ILS Approach is inserted into the active flight plan, and then inserting the IF waypoint using the DIR TO function.

Neither the *FCOM* nor the *FCTM* referred to the possibility that multi-waypoint sequencing of the flight plan and an FMS auto-reset, including the destination runway, could occur during a missed approach. However, having stated as above, the purpose of the *FCOM* and *FCTM* SOPs for the initial approach, as well as the *FCTM* SOP for the leaving Go Around phase is to achieve correct flight plan waypoint sequencing and to ensure a missed approach route is available, should a missed approach or go-around be required. Following a multiple waypoint sequencing, applying these SOPs require the flight crew to reconfigure the FMS with the new approach to be flown and with the destination.

The Investigation recommends that the Operator insert information in their operations and training manuals regarding the possibility of multi-waypoint sequencing of the flight plan and an FMS auto-reset, that could occur during a missed approach, and the essential requirement to reconfigure the FMS flight plan by inserting the required ILS approach thereafter. This reference is required until the revised system description and procedure are available from the manufacturer. According to the manufacturer, the solutions to these problems will be implemented in Airbus A380 FMS L3 std which is planned to be available at the end of 2020 (see sub-section 4.2.1 of this Report).

The FMS problem occurred only on the second approach and was not involved in the initial descent below the cleared altitude occurrence during the first approach.

2.4 Third Approach and Landing

After performing the discontinued approach on the second approach, the flight crew attempted a third approach to the same runway 14R.

After switching the communication to Radar Control, the Radar Controller queried the flight crew as to the reason for the go-around. The Commander replied that the go-around was necessary, as the Aircraft was not stable on the approach. The Commander also requested radar vectors for the third approach, which were subsequently provided by the Radar Controller, as shown in figure 6.

When the Aircraft was on the crosswind leg, maintaining heading 070 degrees (approximately 1.1 nautical miles from the extended runway centerline), at 1819:07, the Approach runway 14R ILS was inserted (temporary insertion).

About 36 seconds later, a lateral revision of the flight plan was made from the Commander's side, by inserting the II14R (IF) waypoint using the DIR TO CRS IN function. Since the Aircraft crosstrack (XTK) position was approximately three nautical miles (XTK was below seven nautical miles) from the runway extended centerline, hence, multi-waypoint (II14R, DD142, UUDD14R, 990 and INTCPT) of the flight plan were sequenced in a row by the FMS, which had also occurred during the preparation for the second approach. On this occasion, no single auto-reset of the FMS occurred.

The difference between the no single auto-reset on this approach and the previous single auto-reset of FMS1, confirmed that the auto-reset of FMS1 on the preparation for the second approach was a real-time computation issue.

When the Aircraft was turning left onto the downwind leg at approximately 8.3 nautical miles from the extended runway centerline, the AO waypoint was inserted using the DIR TO function. Twenty four seconds later, a new destination from the AO waypoint was inserted into the temporary flight plan. The Investigation believes that the Commander performed both insertions. The Investigation believes that these insertions were made to anticipate and prevent a similar FMS auto-reset issue on the third approach attempt.

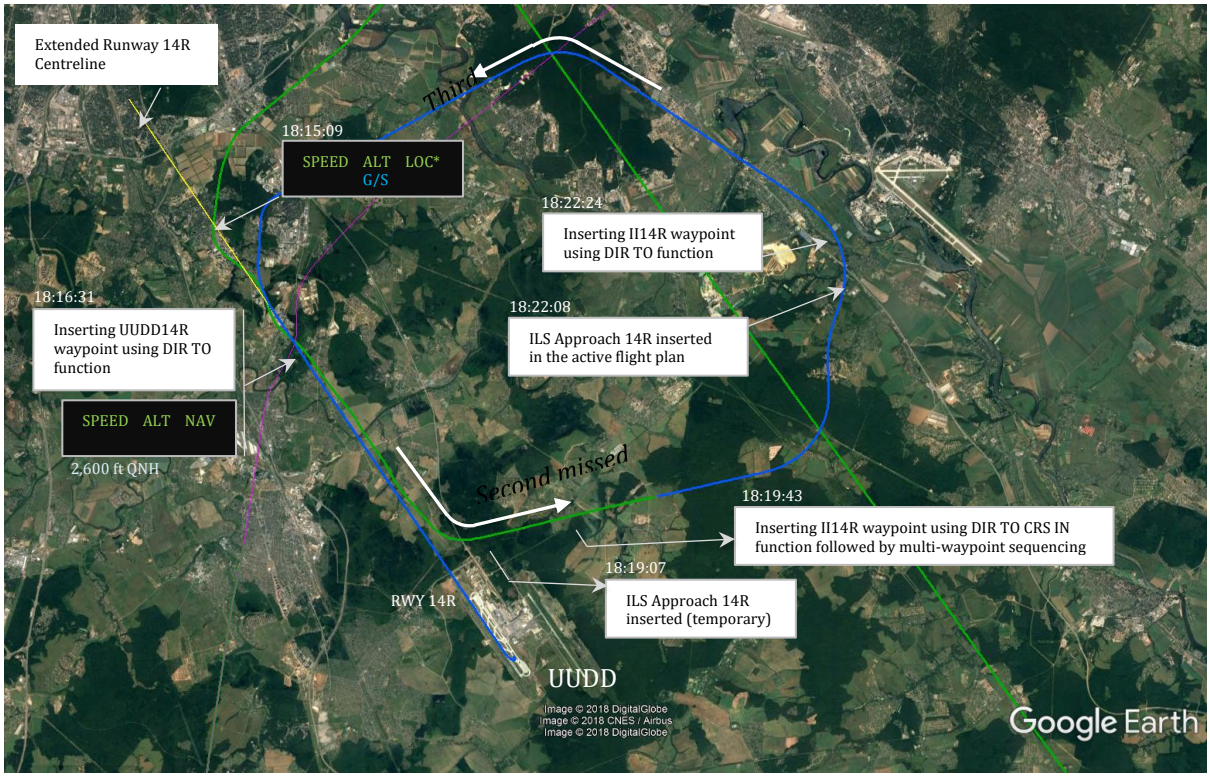


Figure 38. Aircraft trajectory of the discontinued approach, the third approach, and the landing

When the Aircraft was on the downwind leg about 10.2 nautical miles from the runway centerline axis, at 1822:08, Approach runway 14R ILS was inserted into the active

flight plan as per SOP requiring the adjust of the sequencing of the flight plan. Sixteen seconds later, the II14R (IF) waypoint was inserted using the DIR TO function. No multi-waypoint sequencing occurred this time, as the Aircraft crosstrack position from the runway centerline axis was more than seven nautical miles (10.4 nautical miles).

Figure 39 shows the proper glideslope deviation indication for the third approach.

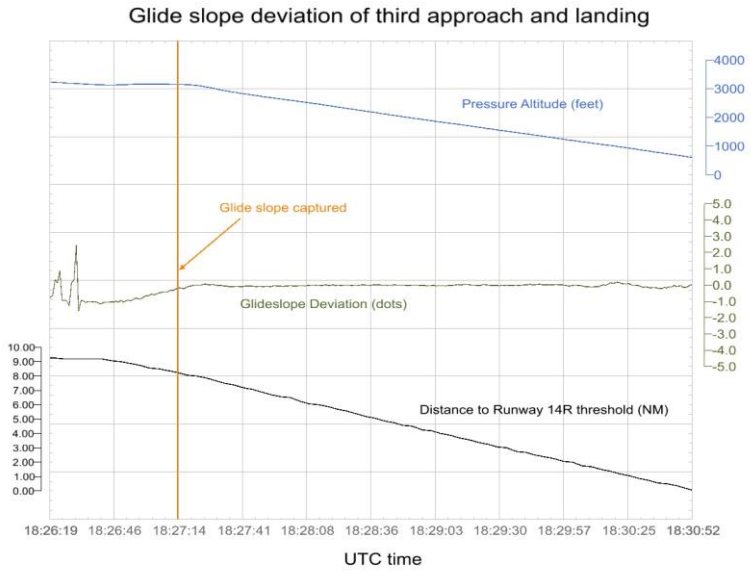


Figure 39. Glideslope deviation for the third approach and the landing

The Aircraft flew as per the approach vectors provided by Radar Control and the Aircraft landed uneventfully.

Compared to the first approach, during the second and third approaches, the deviation of the ILS glideslope signal was not present, as the Aircraft position was within the ICAO envelope.

2.5 Weather

The weather was not a factor in this Incident and all three approaches were performed in visual meteorological conditions (VMC). The Commander stated that he could see the runway lights just before the first go-around was flown. During the second approach, he also saw the PAPI lights (two reds and two whites) after he used the DIR TO function when the Aircraft was about 5.4 nautical miles on the final approach leg. The Co-pilot also saw the PAPI lights during the second approach before carrying out the discontinued approach.

2.6 Training

The *glide interception from above* procedure was included in the Operator's A380 conversion training, and recurrent training and checking.

Based on the training records, both flight crew had attended the required training, which included the *glide interception from above* procedure. The Operator continues the item of *glide interception from above* procedure in the recurrent training using the revised SOP as mentioned in subsection 2.2.5.

The procedure for a 90-degree turn onto the final leg while intercepting the localizer was not particularly included in any training nor published within the Manufacturer's operations documentation. The rationale for this was that this procedure is the same as a normal straight localizer interception.

However, during this event, a vector, which was provided closer to the runway, compared to what was expected from the LIDO runway 14R ILS chart, made both flight crewmembers to feel insecure. This lateral vectoring inside of the FAP at final approach altitude (in this case 3,300 feet QNH or 800 meters QFE) was a concern for the flight crew, since this would have placed the Aircraft high on profile (maintaining final approach altitude of 3,300 feet QNH beyond eight nautical miles from threshold). They perceived that the Aircraft was high and that they did not have enough space to turn the Aircraft to establish on the localizer and capture the glideslope.

Following the Incident, the Operator included additional course material in the recurrent training ground school (RTGS) to highlight awareness, and this occurrence during the first go-around was used as a study case.

2.7 Flight Crew Performance

The Operator incorporated SAFE software to measure pilot fatigue, which included a well-established subjective measuring system using the Samn-Perelli seven-point fatigue scale (SPS). The predicted level of alertness around the time of the approach to UUDD was between SPS “3.0 means okay, somewhat fresh” and “4.0 means a little tired, less than fresh” for both flight crewmembers. The SAFE prediction was in line with the flight crew feedback regarding their level of alertness.

The flight schedules and the fatigue data for both flight crewmembers indicated that they were adequately rested and alert at the time of the approach at UUDD.

Since the CVR recorded data of the flight was not available, the Investigation was limited in assessing flight crew communication, cockpit authority gradient, efficiency and effectiveness in the performance of checklists, briefings, call outs, and in the interaction between the Commander and the Co-pilot.

However, with the availability of the DFDR data, ATC voice recording, FMS BITE data, interviews, and the analysis as discussed in the previous paragraphs, it was found that:

- The Aircraft was properly configured during all approaches and during the landing;
- There was a lack of proper planning on the part of both flight crew regarding how to establish the Aircraft on the runway 14R ILS considering the tight approach as vectored.
- Several required call outs and announcements were not performed by both flight crew;
- The prerequisite condition of the *glide interception from above* procedure was not followed by the Co-pilot when he commenced the procedure;
- Both flight crew were not aware of the ICAO envelope of glideslope signal coverage, the requirement to re-insert the runway 14R ILS approach, and the multi-waypoint sequencing when the Aircraft crosstrack position was less than 7 nautical miles; and
- Both flight crew did not refer to and confirm the Aircraft vertical position using other available indications.
- The Controller’s communications were understandable by the flight crew, however, the “not to descend further” instruction was lengthy and the phraseology used was non-standard for an urgent instruction.

2.8 Flight Recorder Preservation

Following the Incident, the Operator did not have the opportunity to preserve the flight recorders (FDR and CVR) as per the requirements of *CAR-OPS 1* of the *Civil Aviation Regulations* and the *Operations Manual – Part A*. The flight crew, possibly, did not consider the event as a 'serious incident' at this stage, despite the available evidence. They notified the Operator of the event by submitting an electronic air safety report (ASR) after the Aircraft had taken off for the return flight to OMBD. However, the report did not mention the seriousness of the event.

The Aircraft returned first to OMDB, and then the Operator notified the Air Accident Investigation Sector (AAIS) about the Incident. The AAIS requested the Operator to preserve both flight recorders.

Since the CVR had only two hours recording capability, the available data on the CVR was the last two hours of the flight from UUDD to OMDB (return flight), and the recorded data from the Incident flight had been overwritten.

The FDR had a recording capability of 72 hours. Therefore, the flight data for the Incident flight was available and was useful to the Investigation.

The Investigation believes that had the flight crew notified the Operator promptly the Operator would have had the opportunity to notify the AAIS immediately after the Incident. Hence, the AAIS would have requested the Operator to preserve both flight recorders. In order to prevent reoccurrence of flight recorders preservation issue as experienced in this Incident, the Investigation recommends that the Operator re-inforce the implementation of flight recorder recordings preservation process to be implemented as appropriate following a serious incident particularly, as this is required as per *CAR-OPS 1* requirements and the *Operations Manual – Part A*.

3. Conclusions

3.1 General

From the evidence available, the following findings, causes and contributing factors were made with respect to this Incident. These shall not be read as apportioning blame or liability to any particular organization or individual.

To serve the objective of this Investigation, the following sections are included in the conclusions heading:

- **Findings.** Statements of all significant conditions, events or circumstances in this Incident. The findings are significant steps in this Incident sequence but they are not always causal or indicate deficiencies.
- **Causes**. Actions, omissions, events, conditions, or a combination thereof, which led to this Incident.
- **Contributing factors.** Actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the Incident occurring, or mitigated the severity of the consequences of the Incident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability.

3.2 Findings

3.2.1 Findings relevant to the Aircraft

General

(a) The Aircraft was certified, equipped and maintained in accordance with the requirements of the *Civil Aviation Regulations* of the United Arab Emirates.

(b) The Aircraft was airworthy when dispatched for the flight.

(c) The available CVR recording data was not useful to the Investigation.

First Approach

(d) The ILS glideslope signal was unreliable during the period of the first approach and the go-around, due to the Aircraft being outside the azimuthal coverage until the Aircraft crosstrack position reached 6.7 nautical miles.

(e) When the Aircraft came within the azimuthal coverage, it was outside the elevation coverage of the ICAO envelope, until reaching 6.7 nautical miles XTHR.

Second Approach

(f) After the first go-around, FMS1 (Commander side) was automatically reset after multi-waypoint sequencing in a row of the flight plan, following a lateral revision of the flight plan by the Commander shortly after the first go-around.

(g) The FMS2 (FMC-B) and backup on standby (FMC-C) remained in nominal condition during the FMS1 auto-reset.

(h) The flight plan was not displayed on the Commander's side as a consequence of the FMS1 reset after multi-waypoint sequencing, but was still displayed on the Co-pilot's ND and MFD.

(i) Nominal operation of dual FMS was fully recovered approximately 32 seconds after the single FMS1 auto-reset as the last operation prior to the reset.

(j) The multi-waypoint sequencing was the result of a lateral revision of the flight plan using the DIR TO CRS IN function and a logic included in the FMS enabling the sequencing of a flight plan waypoint when it was not strictly followed by the Aircraft. This is as per the system design.

(k) The Aircraft experienced localizer oscillations as the localizer capture mode was engaged late by the AFS.

(l) The late engagement of localizer capture mode was due to the multi-waypoint sequencing of the flight plan combined with a FMS auto-reset on the Commander's side. This caused the FMS to send erroneous data to the LOC capture control law performed by the Flight Guidance and Control computer (PRIM).

(m) Re-inserting the approach in the flight plan after the FMS1 auto-reset was required by the system and the SOP in order to update the destination runway with a correct position. The approach was not re-inserted.

Third Approach

(n) The difference result of the multi-waypoint sequencing on this third approach compared to the one that occurred on the second approach, confirmed that the auto-reset of FMS1 on the second approach was a real-time computation issue.

3.2.2 Findings relevant to the flight crew

General

(a) The flight crewmembers were licensed and qualified for the flight in accordance with the existing requirements of the *Civil Aviation Regulations* of the United Arab Emirates.

(b) Both flight crewmembers possessed valid Class 1 medical certificates.

First Approach

(c) The expectation of the Co-pilot, as the pilot flying, that the Radar Control might not provide the flight crew with vectors to intercept the localizer on the base leg at 90-degrees to the final approach track, and the provided radar vectors inside the FAP including maintaining high speeds until the Aircraft was almost abeam with the IAF as per ATC instruction, resulted in an unusual high workload in a dynamic approach phase.

(d) Divergence of flight crew shared mental model in managing the ILS approach due to insufficient communication and coordination between them.

(e) It is most likely that the Co-pilot erroneously focused on the glideslope deviation indication, as it supported his mental model and confirmed his expectation that the Aircraft was high on the vertical profile of the ILS approach.

Second Approach

(f) After the multi-waypoint sequencing of the flight plan and the FMS1 auto-reset during the second attempted approach, the flight crewmembers omitted to reconfigure the FMS by inserting (adjusting the sequencing of the flight plan) the runway 14R ILS approach. The flight crew did not anticipate that omitting this action, aiming at providing the missed approach route should a go-around

need to be performed, would jeopardize the capture of the localizer by the AFS system.

(g) On the second approach, the three-localizer oscillations surprised the flight crew, as these were unexpected.

(h) The Commander was not comfortable with Aircraft state, as the flight plan was not displayed on the FMS and the subsequent occurrence of the localizer oscillations. These items led him to believe that he needed to direct the Aircraft to the runway in the FMS by selecting the UUDD14R waypoint using the DIR TO function. With the insertion of the runway waypoint (UUDD14R), the Commander intended to have FMS position data displayed on the ND.

(i) The Commander expressed his concern to the Co-pilot about the FMS issue; however, he did not announce his intention to the Co-pilot before he applied the DIR TO function in the FMS.

(j) The first go-around experience, the relatively high workload during the second approach and preparing for the landing, and the FMS and localizer oscillations affected and added to the Commander's stress level. His stress level may have reached a point that led to anxiety and a reduction in his performance, which affected his judgement, attention, memory and concentration. Consequently, he overlooked the need to inform to the Co-pilot before using the DIR TO function and then he lost his awareness of what had happened to the Aircraft.

3.2.3 Findings relevant to flight operations

3.2.3.1 First approach and go-around

(a) During the descent for the arrival at UUDD, the Aircraft was provided with wide vectoring by Radar control due to busy traffic around UUDD.

(b) For the approach, the Aircraft was vectored closer to the runway compared to the instrument approach depicted on the runway 14R ILS chart. On the base leg, the given vectoring was approximately parallel to the IAF-IF line as given on the runway 14R ILS chart.

(c) The Aircraft was vectored to an 85-degree turn onto the final leg for the instrument approach to UUDD runway 14R.

(d) When the Aircraft was flying the last part of the arrival segment, Radar control offered the option to the flight crew of descending to 500 meters, which was accepted by the Commander.

(e) When the Aircraft was abeam the initial approach fix point (AMTAM waypoint) as per the runway 14R ILS chart, the Commander became concerned about the 85-degree intercept angle and the airspeed of 170 knots, which he considered high, and therefore, the managed speed mode was selected.

(f) Both flight crewmembers were concerned that the Aircraft would be high when it reached the final approach leg.

(g) The Co-pilot thought that a higher airspeed was needed in order to expedite the descent while in open descent mode and he planned to maintain the 170 knots selected airspeed until the Aircraft captured the glideslope.

(h) The Co-pilot's perception of a required higher airspeed was the reason he set the 170 knot selected mode as he wished to establish the Aircraft on the localizer as soon as possible.

(i) The Commander observed that the Co-pilot selected the airspeed to 170 knots, but he did not question the purpose of the Co-pilot's action.

(j) After 170 knots airspeed was selected, the Co-pilot performed the *glide interception from above* procedure in a situation where the Aircraft was not yet established on the localizer of the runway 14R ILS. The localizer mode was armed as displayed on the FMA when he performed the procedure.

(k) Before performing the *glide interception from above* procedure, the Co-pilot referred only to the glideslope deviation indication displayed on the PFD that showed more than one dot above ILS glide profile, where the ILS glideslope signal was not yet reliable and accurate.

(l) The Co-pilot did not confirm the correct Aircraft vertical position by checking other available indications such as the pressure altitude, navigation and vertical display, or the approach procedure chart.

(m) The Co-pilot's action in carrying out the procedure was because he thought that the Aircraft was high as indicated by the invalid glideslope deviation, and his perception that the Aircraft would be established on the localizer very soon, in about three to four seconds.

(n) In fact, the actual Aircraft position was already below the 3-degree glideslope, and the Aircraft would have established on the localizer far beyond his expectation.

(o) The Aircraft would have established on the localizer approximately 63 seconds from the time the Co-pilot set the selected altitude to 3,000 feet (commencing the *glide interception from above* procedure), only if the Aircraft had maintained 500 meters as instructed by Radar Control, which was not the case in this Incident.

(p) The Co-pilot performed the *glide interception from above* procedure without the prerequisite condition of localizer establishment, due to false perception that the Aircraft would be established on the localizer very soon (about 3 to 4 seconds).

(q) The Radar Controller contacted the flight crew when the Co-pilot had just performed the *glide interception from above* procedure that was unknown to the Commander.

(r) It was approximately in the middle of the Radar Controller's radio contact when the glideslope deviation indication showed the Aircraft to be on the ILS glideslope profile and continued descending below the profile.

(s) After carrying out the procedure, the Co-pilot focused on the heading of the Aircraft to establish on the localizer course, and on the Aircraft configuration. He focused on these without monitoring the correct glide capture by the AFS as per SOP, requiring a check of the glideslope capture mode engagement by AFS when the glideslope deviation went close to null deviation (on profile), and to take over when the glideslope deviation was continuing to increase beyond the PFD's scale. The displayed glideslope deviation crossed almost the full scale from above to below without engagement of the expected glideslope capture mode.

(t) The Co-pilot improvised by carrying out the *glide interception from above* procedure did not help the Commander, as the pilot monitoring, to perform the monitoring adapted to his particular maneuver. Hence, no action by either flight crewmember took place to stop the Aircraft from descending.

(u) Radar Control contacted EK131, as the Commander did not reply to the previous radio communication. At this time, the Aircraft was descending below 500 meters QFE, and was instructed not to descend further.

(v) Neither flight crewmember was aware that the Aircraft was descending below 500 meters QFE.

(w) During the Radar Controller's instruction to terminate the descent the Commander became aware of the Aircraft height. The Co-pilot was made aware of the Aircraft vertical position when the Commander requested him to engage the altitude hold mode.

(x) The Commander decided to initiate a go-around, which the Co-pilot then carried out using the 'soft go-around' technique, and the Commander declared the go-around to the Radar Controller.

(y) After the go-around was initiated, EGPWS cautions of "Glideslope" aural alert and 'GLIDE SLOPE' (in amber) visual alert appeared on the PFD for two seconds, then the "Terrain Ahead - Pull Up" aural alert triggered by a TAD warning and a 'TERRAIN' (in red) visual alert appeared on both NDs for six seconds, and lastly another one second EGPWS "Glideslope" alert occurred.

(z) The minimum radio altitude reached was 395 feet above ground level during the first glideslope cautionary alert appearance, and shortly after the Aircraft started to climb, the "Terrain ahead, pull up" warning appeared for six seconds.

(aa) Before the go-around was initiated, the localizer track mode and/or localizer capture mode never engaged, hence, the glide slope track mode and/or glide slope capture mode were not engaged by the system.

(bb) Following the go-around, the flight crew requested radar vectoring for a longer final approach and they intended to land on the same runway 14R.

3.2.3.2 Second approach and discontinued approach

(a) After the go-around, when the Aircraft was approximately six nautical miles from the extended runway centerline, the Approach phase was activated in the FMS.

(b) When the Aircraft was approximately 7.5 nautical miles from the extended runway centerline (crosstrack position), a lateral revision of the flight plan was carried out from the Commander's side by inserting the starting point of the intermediate approach segment (IF or II14R waypoint).

(c) Multi-waypoint sequencing in a row of the flight plan occurred when the lateral revision was performed by the Commander shortly after the go-around using the DIR TO CRS IN function and the Aircraft crosstrack position was below seven nautical miles due to vectoring, and was then followed by an automatic reset on FMS1.

(d) After multi-waypoint sequencing of the flight plan occurred, the FMS was not reconfigured by inserting the ILS 14R approach to perform the attempted second approach. This was required before capturing the localizer, in order to obtain the correct position of runway 14R as the destination.

(e) When the Aircraft turned left from the base leg onto the final approach leg, the localizer capture mode was engaged late by the AFS.

(f) The glide slope track mode was engaged just before the Aircraft reached the final approach point (P) with the engagement of the localizer capture mode. However, the localizer track mode did not engage during the second approach.

(g) The localizer overshoot and the oscillations of the Aircraft flight path occurred on the final approach leg because the FMS sent erroneous data (using zero latitude and longitude of the destination runway position) to the LOC capture control law. Re-inserting the ILS 14R approach in the flight plan after the FMS1 auto-reset was required to update the destination runway 14R with a correct position.

(h) The Commander's use of the DIR TO function resulted in disengagement of the localizer capture and glide slope track modes, and engagement of the altitude hold mode and navigation mode, hence, the approach discontinued and the Aircraft stopped descending on the glideslope.

(i) Discussion between the flight crew took place after using DIR TO function, and at the end of the conversation, the Aircraft was already high on the glideslope. The Co-pilot proposed a new approach, and the Commander agreed and decided to perform a discontinue approach.

3.2.3.3 Third approach and landing

(a) When the Aircraft was turning onto the crosswind leg, UUDD was inserted as a new destination for the active flight plan.

(b) When the Aircraft was just on the crosswind leg, Approach ILS 14R was inserted (temporary insertion).

(c) When the Aircraft was on the crosswind leg about three nautical miles from the runway centerline axis, a lateral revision of the flight plan was carried out from the Commander's side by inserting the II14R (IF) waypoint using the DIR TO CRS IN function. The Aircraft crosstrack (XTK) position was about three nautical miles, hence, multi-waypoints of the flight plan were sequenced in a row by the FMS. However, no FMS auto-reset occurred.

(d) When the Aircraft was on the downwind leg about 10.2 nautical miles from the runway centerline axis, the Approach runway 14R ILS was inserted into the active flight plan as per SOP requiring adjustment of the sequencing of the flight plan. The II14R (IF) waypoint was inserted using the DIR TO function. No multi-waypoint sequencing occurred, since the Aircraft crosstrack position was more than seven nautical miles (10.4 nautical miles) from the runway centerline axis.

(e) The Aircraft performed a normal runway 14R ILS approach and landed uneventfully from the third approach.

3.2.4 Findings relevant to air traffic control

(a) The vectors for the first approach was almost parallel to the IAF-IF line of the ILS 14R initial approach segment and put the Aircraft on the base leg approximately 2.9 nautical miles closer to the runway compared to the LIDO instrument approach chart of the runway 14R ILS.

(b) When the Aircraft continued descending below 500 meters QFE, the Radar Controller, most likely, sensed the urgency of the situation and instructed EK131 to stop descending. The duration of the Radar Controller's instruction was about 17 seconds, which is long for an urgent instruction.

(c) For the first approach, Radar control did not provide the final vector (heading) to intercept the localizer as per ICAO Doc 4444.

(d) For the second approach, Radar control provided approach vectors, which were almost the same as the path of the published LIDO instrument approach chart for the runway 14R ILS.

(e) For the second and third approach, Radar control provided the final vector to intercept the localizer as per ICAO Doc 4444.

(f) For the third approach, Radar Control provided approach vectors, which were almost the same as those of the first approach, but slightly wider.

3.2.5 Findings relevant to weather conditions

(a) The weather was not a factor in this Incident, and all three approaches and the landing were performed in visual meteorological conditions (VMC).

3.2.6 Findings relevant to the Operator

(a) Following the Incident, the Operator did not have the opportunity to preserve the flight recorders (FDR and CVR) as per the requirements of CAR-OPS 1 and the procedures of Operator's Operations Manual – Part A.

(b) The Aircraft first returned to OMDB, and then the Operator notified AAIS about the Incident. AAIS then requested the Operator to preserve both flight recorders.

3.3 Causes of the Incident

The Air Accident Investigation Sector determines that:

(a) The descent below the cleared altitude on the first approach can be explained by an erroneous flight crew perception that the Aircraft would capture the 3° glideslope from above and by insufficient coordination between the flight crewmembers. After the Co-pilot carried out the *glide interception from above* procedure, he focused on the horizontal position of the aircraft to establish on the localizer and neither of the two pilots maintained a correct awareness of the Aircraft vertical position.

(b) The cause of the discontinued approach on the second approach was the selection by the flight crew of a waypoint using the DIR TO function and after a relatively long discussion between them due to:

- the unavailability of the flight plan on the ND, as the FMS1, reset after the go-around, was not reconfigured by re-sequencing the flight plan as per SOP; and
- the Aircraft oscillation around the localizer course.

3.4 Contributing Factors to the Incident

The Air Accident Investigation Sector identifies the following contributing factors to the Incident:

(a) The expectation of the Co-pilot that Radar Control might not provide the flight crew with vectors to intercept the localizer at an angle of 45 degrees or less when the Aircraft was on the base leg (90-degrees to the final approach track). The provided radar vectors inside the final approach point (FAP) together with the instruction to maintain relatively high speeds until the Aircraft was almost abeam of the initial approach fix (IAF), and the Co-pilot expectation, resulted in an unusually high workload in a dynamic approach phase.

(b) The glide interception from above procedure was performed when the Aircraft had not yet established on the ILS localizer for runway 14R. This was not in accordance with the SOP.

(c) During the period of when the *glide interception from above* procedure was performed and the go-around, the Aircraft position was initially outside the azimuthal coverage of the ILS glideslope signal, and when the Aircraft came within azimuthal coverage, it was outside the elevation coverage of the glideslope signal. Consequently, invalid glideslope deviation indications were displayed to the flight crew.

(d) Before performing the glide interception from above procedure, the erroneous flight crew representation of the Aircraft position gave them the perception that they were being vectored to a tight approach and that the Aircraft would capture the glideslope from above, led the pilot flying:

- to refer only to the glideslope deviation indication to determine the Aircraft vertical position instead of considering and crosschecking any other available indications (pressure altitude, vertical and navigation displays, and the DME distance table in the approach chart) which would have enabled him to reconsider and validate the Aircraft position; and
- to descend below the cleared altitude and to modify the heading vectors issued by the Air Traffic Controller.

(e) As the Aircraft was descending below 500 meters QFE, the duration of the Radar Controller's instruction to the flight crew "not to descend further" was lengthy and the phraseology used was non-standard for an urgent instruction,

(f) As the flight crew prepared for the second approach, a multi-waypoint sequencing in a row of the flight plan occurred when the crew performed a lateral revision of the flight plan using the DIR TO CRS IN pushbutton as per the SOP at a location where several waypoints satisfied the FMS geometrical waypoint sequencing rules. A real time computation issue caused an automatic reset of FMS1.

(g) After the multi-waypoint sequencing of the flight plan and the FMS1 auto-reset during the second attempted approach, the flight crewmembers omitted to reconfigure the FMS by inserting (adjusting the sequencing of the flight plan) the runway 14R ILS approach. The flight crew did not anticipate that omitting this action, aiming at providing the missed approach route should a go-around need to be performed, would jeopardize the capture of the localizer by the AFS system.

4. Safety Recommendations

4.1 General

The safety recommendations listed in this Report are proposed according to paragraph 6.8 of *Annex 13 to the Convention on International Civil Aviation*, and are based on the conclusions listed in heading 3 of this Report; the GCAA AAIS expects that all safety issues identified by the Investigation are addressed by the concerned organizations.

4.2 Safety Actions

The following safety actions were taken by the Aircraft Manufacturer and the Operator after the Incident occurred.

4.2.1 Safety Actions taken by the Aircraft Manufacturer

Based on the findings regarding the FMS multi-waypoint sequencing of the flight plan and the FMS auto-reset, two mitigations are under review by the Aircraft manufacturer;

- For the design aspect: the rectification and implementation will be discussed with the supplier (FMS manufacturer) for incorporation at the next FMS standard update.
- For the operational aspect: a system description and development of procedures are under review taking into account that a nominal situation is recovered if the FMS is reconfigured to perform the approach after the single FMS auto-reset.

The auto-reset was confirmed by the FMS manufacturer/supplier as a real time computation issue, and not systematic. This problem had already been identified as being applicable to FMS provided by this supplier and equipping other Airbus programs.

A rectification has been developed, certified and entered into service on Airbus A330 and A350 FMS standards.

The solution will be implemented on the Airbus A380 FMS L3 standard and is planned to be available at the end of 2020.

4.2.2 Safety Actions taken by the Operator

The Operator took safety actions following the Incident by conducting an internal evaluation of the Incident, during the course of the Investigation.

a. The Flight Operations Department reviewed the procedure to intercept the glideslope from above and current differences between fleets with the view to harmonizing the procedure and aligning it with best industry practice. A review of recent industry events and reports highlighted the risks from approach path intercept from above and the importance of procedures for air navigation system – aircraft operations (PANS-OPS) compliance to mitigate these risks. The *FCOM* and *FCTM* were revised to ensure that the SOP explains that the *glide interception from above* procedure must only be applied when established on the localizer. The revision also includes that applying the procedure is only authorized down to the charted FAF/FAP, the charted Descent Point or the ATC cleared approach intercept altitude.
b. In order to enhance flight crew awareness of the threat of using ILS indications outside the certified envelope, a Flight Safety Update was published in January 2018. The lowest angle of ILS elevation coverage was included in the *FCOM* in the Approach section. The Operator has trained the

pilots the additional ILS coverage, including reviewing this Incident flight with a detailed explanation of localizer and glideslope design and use criteria. The "descent below the glideslope" was included in the current ground school day.

c. The Operator included additional course material in the recurrent training ground school (RTGS) to highlight awareness, and the occurrence during the first go-around was used as a study case.
d. The SOP for a discontinued approach was unavailable in the *FCOM* during the Incident. Following the Incident, the Operator added the related SOP in the *FCOM*.

4.3 Final Report Safety Recommendations

The Air Accident Investigation Sector issues the following safety recommendations to the named organizations:

4.3.1 Emirates

SR41/2020

Neither the *FCOM* nor the *FCTM* referred to the possibility that multi-waypoint sequencing of the flight plan which includes the destination runway, together with an FMS auto-reset, could occur during a missed approach.

The purpose of the current *FCOM* and *FCTM* SOPs for the initial approach, as well as the *FCTM* SOP for the leaving Go Around phase, is to achieve correct flight plan waypoint sequencing and to ensure that a missed approach route is available, should a missed approach or go-around be required.

Following a multiple waypoint sequencing, applying these SOPs required the flight crew to reconfigure the FMS with the new approach to be flown, and also with the destination.

Therefore, it is recommended that information be added to the operations and training manuals regarding the possibility of multi-waypoint sequencing of the flight plan, and the FMS auto-reset that can occur during a missed approach. This sequence of events requires reconfiguration of the FMS flight plan by inserting the required ILS approach to adjust the flight plan sequencing.

The above information should be included in the operations and training manuals until the revised system description and procedures are available from Airbus.

SR42/2020

The flight crew did not consider the event to be a 'serious incident', despite the available evidence. They notified the Operator of the event by submitting an electronic air safety report (ASR) after the Aircraft had taken off for the return flight to OMBD. However, the report did not mention the seriousness of the event. This resulting in the flight recorders not being preserved. In consequence, as the cockpit voice recorder had a two-hour recording capability, information relevant to the investigation was overwritten and was therefore unavailable.

It is recommended that the Operator re-inforce among its pilot body the requirements of *CAR-OPS 1* and the *Operation Manual – Part A* procedures regarding the preservation of flight recorder recordings as evidence.

4.3.2 Domodedovo Air Traffic Control

SR43/2020

As the Aircraft descended below its cleared altitude of 500 meters during the first approach, the Controller could have transmitted a shorter urgent instruction in standard terminology. This would have facilitated the flight crew in that they would have had more time to react to recover the situation. Therefore, it is recommended that ATC management emphasize to the Controllers to use only standard terminology in all communications.

SR44/2020

During the first approach, the Radar Controller did not provide a proper last vector (heading instruction) that might have resulted in an 85-degree localizer intercept angle, which did not comply with ICAO Doc 4444.

It is recommended that Controllers provide a series of headings including the final vector that should result in a localizer intercept angle with a final approach track of 45 degrees or less, in accordance with ICAO Doc 4444.

4.3.3 Airbus

SR45/2020

The ICAO ILS glideslope envelope elevation coverage lowest angle was not included in the Airbus *FCOM*. In order to ensure sufficient glideslope beam quality for a normal capture for all operators, it is recommended to include the definition of the ICAO envelope elevation coverage lowest angle in the operations manual.

SR46/2020

According to the Manufacturers' *FCOM*, the *glide interception from above* procedure should only be applied when the Aircraft is established on the localizer. The term "should" in the Manufacturers' *FCOM* was not strong enough to emphasize the threat when the procedure was applied outside of the certified ILS envelope.

In order to ensure that all Airbus A380 aircraft operators perform the procedure correctly, it is recommended to emphasize to pilots the necessity of ensuring that the aircraft is established on the localizer as a mandatory prerequisite action to apply the *glide interception from above* procedure. The manufacturer should update the procedure in the operations manual.

This Report is issued by:
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Appendix 1. Detailed Event Descriptions

The detailed event descriptions based on the relevant DFDR read-out, analysis of the FMS BITE data and ATC voice recording data were examined as described below. Prior to that, the time between the DFDR, FMS BITE data, and ATC voice recording data were synchronized.

The Aircraft lined up on runway 30R for departure, and at about 1314:22, the flight crewmembers commenced the takeoff.

During cruise phase, approach data for UUDD ILS runway 14R was prepared and inserted on the FMS PERF Approach page, as the following:

- Wind 170º / 8 knots
- Outside air temperature (OAT) = 15º
- QNH 1015
- Decision altitude (DA) = 800 feet

Initial Approach of ILS 14R and Go-around

Before 1720:35, Autothrust (A/THR), autopilot (AP2), both flight directors, FMS, navigation managed mode, speed managed mode, and altitude hold of the cruise flight level of 38,000 feet (ALT CRZ mode) were engaged. FMS2 was the master for FMS guidance. The indications displayed on the FMA were: MACH (autothrust was in speed mode), AP2, NAV, ALT CRZ.

The indicated active waypoint (left and right) was NERAN on the FMS flight plan.

At 1720:35, while the Aircraft was cruising at FL380, the selected altitude was changed from 38,000 to 26,000 feet by rotating the ALT knob on the AFS CP. The airspeed was 274 knots, as the managed speed mode.

At 1720:40, ALT knob was pushed on the AFS CP, which engaged the descent managed mode in geometric path (DES appeared on FMA). The altitude hold mode of cruising FL380 became disengaged, hence ALT CRZ disappeared on FMA. The altitude hold mode became armed (ALT displayed on the FMA).

The managed target speed controlled by the FMS was 274 knots. The commanded thrust on all engines decreased. After 10 seconds the target speed increased gradually to 300 knots and reached the target at 1723:57. The target vertical speed controlled by the FMS changed from 0 to -1,000 feet/minute (fpm) gradually. The vertical speed reached -1,000 fpm at 1721:02. The autothrust controlled the Mach target (MACH on the FMA), hence, the commanded thrust continuously changed to manage the increment of the target Mach. The autopilot controlled the vertical trajectory. The vertical trajectory was a result of speed/Mach and of thrust.

At 1720:46, the Aircraft consequently started to descend from the top of descent, FL380. The airspeed was 274 knots.

At 1720:51, the indicated active waypoint was NEMRI on the FMS flight plan.

At 1723:07, the indicated airspeed reached 289 knots as the target airspeed managed by FMS (Flight Guidance).

At 1723:24, autothrust controlled the engines applying thrust slightly highest than idle thrust. THR DES displayed and MACH disappeared on the FMA.

At 1723:51, the indicated active waypoints were GORBA on the FMS flight plan.

At 1725:43, the indicated active waypoints were FE on the FMS flight plan.

Between 1728:12 and 1728:14, the selected altitude was changed from 26,000 to 19,000 feet by rotating ALT knob on the AFS CP, while the Aircraft was descending through 26,500 feet and the airspeed was 300 knots.

At 1728:29, THR DES disappeared and SPEED appeared on the FMA. It means at this time, the autothrust managed the engines thrust to control the target speed.

At 1728:35, the indicated active waypoints were AO on the FMS flight plan.

At 1729:28, speed (SPD) knob was pulled to engage the speed selected mode, and this resulted in speed managed mode became disengaged. Thereafter, the selected speed was set to 250 knots by rotating SPD knob on the AFS CP, and consequently, the airspeed started to decrease from 300 knots.

At 17:29:30, autothrust managed the engines applying idle thrust. THR IDLE appeared and SPEED disappeared on the FMA.

At 1729:35, ALT knob was pulled which engaged open descent vertical selected mode (OP DES), and descent vertical managed mode (DES) became disengaged. On the FMA, OP DES appeared and DES disappeared. The Aircraft was descending through 24,130 feet.

At 1732:08, the airspeed reached approximately 250 knots and maintained, while the Aircraft was descending through 21.736 feet pressure altitude.

Between 1733:10 and 1733:11, ALT knob was rotated to change the selected altitude target from 19,000 to 16,000 feet, while the Aircraft was descending through 20,430 feet with a constant airspeed of 250 knots.

At 1734:20, ALT knob was rotated. to change the selected altitude target from 16,000 to 15,000 feet, while the Aircraft was descending through 18,960 feet with a constant airspeed of 250 knots.

Between 1734:21 and 1734:24, SPD knob was rotated to change the selected speed target from 250 to 230 knots, which consequently, the airspeed thereafter started to decrease.

At 1735:21, the airspeed reached approximately 230 knots and maintained, while the Aircraft was descending through 18.396 feet pressure altitude.

At 1736:08, ALT knob was rotated to change the selected altitude target from 15,000 to 13,000 feet, while the Aircraft was descending through 17,620 feet with a constant airspeed of 230 knots.

At 1737:00, ALT knob was rotated to change the selected altitude target from 13,000 to 12,000 feet, while the Aircraft was descending through 16,470 feet and the airspeed was 232 knots.

At 1737:42, heading (HDG/TRK) knob was pulled resulted in engagement of heading selected mode (HDG displayed on FMA), and the navigation managed mode became disengaged (NAV disappeared on FMA). Thereafter, the selected heading was set to 340 from 325 degrees by rotating HDG knob on the AFS CP, and consequently, the Aircraft started to turn right. The Aircraft was descending through 15,690 feet and the airspeed was 230 knots.

At 1739:07, ALT knob was rotated to change the selected altitude target from 12,000 to 11,000 feet, while the Aircraft was descending through 14,100 feet with a constant airspeed of 230 knots.

Between 1739:12 and 1739:18, SPD Knob was rotated to change the selected speed target from 230 to 200 knots, which consequently, the airspeed thereafter started to decrease.

At 1739:23, the indicated active waypoints were R021 on the FMS.

At 1741:41, the LS pushbutton on Co-pilot side was pressed, hence, the localizer and glideslope signal became available, and the deviations appeared on the PFD.

At 1740:41, ALT knob was rotated to change the selected altitude target from 11,000 to 10,000 feet, while the Aircraft was descending through 13,260 feet. The airspeed just reached 200 knots and maintained.

At 1742:03, HDG knob was pulled (actually it is not necessary since the HDG mode was already engaged) resulted in disengagement and then engagement again of the selected heading mode. Consequently, NAV mode became engaged and then disengaged again in one second.

At 1742:07, the indicated active waypoints were ABMAS on the FMS.

At 1742:37, ALT knob was rotated to change the selected altitude target from 10,000 to 9,000 feet, while the Aircraft was descending through 11,360 feet with an airspeed of 200 knots.

At 1742:53, the LS pushbutton on Commander side was pressed, hence, the localizer and glideslope signal became available, and the deviations appeared on the PFD.

At 1744:16, ALT knob was rotated to change the selected altitude target from 9,000 to 8,000 feet, while the Aircraft was descending through 9,790 feet. The airspeed was 200 knots.

At 1745:28, flaps lever position was set to configuration '1'. Hence, slats/flaps started to move from 0º/0º. The flaps reached 8 degrees at 1745:55, while the slats reached 20º at 1746:05.

Between 1745:34 and 1745:42, SPD knob was rotated to change the selected speed target from 200 to 180 knots, which consequently, the airspeed thereafter started to decrease. The Aircraft was descending through 8,450 feet when SPD knob was started rotated.

At 1745:59, approach phase was activated on FMS by selecting and confirming ACTIVATE APPR * prompt displayed on the MFD PERF page. The Aircraft was descending passing 8,284 feet, and the airspeed was decreasing through 187 knots.

At 1746:15, the Aircraft was descending through 8,100 feet, and it triggered the engagement of altitude capture mode, ALT* displayed on the FMA, which means that the Aircraft reached the capture zone of the selected attitude of 8,000 feet, as set on the AFS CP. The altitude hold mode became disarmed (ALT disappeared on the FMA).

Autothrust managed the engines thrust to control the target speed. THR IDLE disappeared and SPEED appeared on the FMA. Consequently, the open descent mode became disengaged (OP DES disappeared on the FMA).

At 1746:20, a lateral revision of the flight plan was performed by inserting II14R (IF) waypoint using the DIR TO CRS IN function from Commander side. The pressure altitude was 8,080 feet, and the airspeed just reached 180 knots. The FMS flight plan displays on the MFD and ND were as given in figure A1.1 below. The DIR TO CRS IN is a FM function used to help capturing the LOC (localizer).

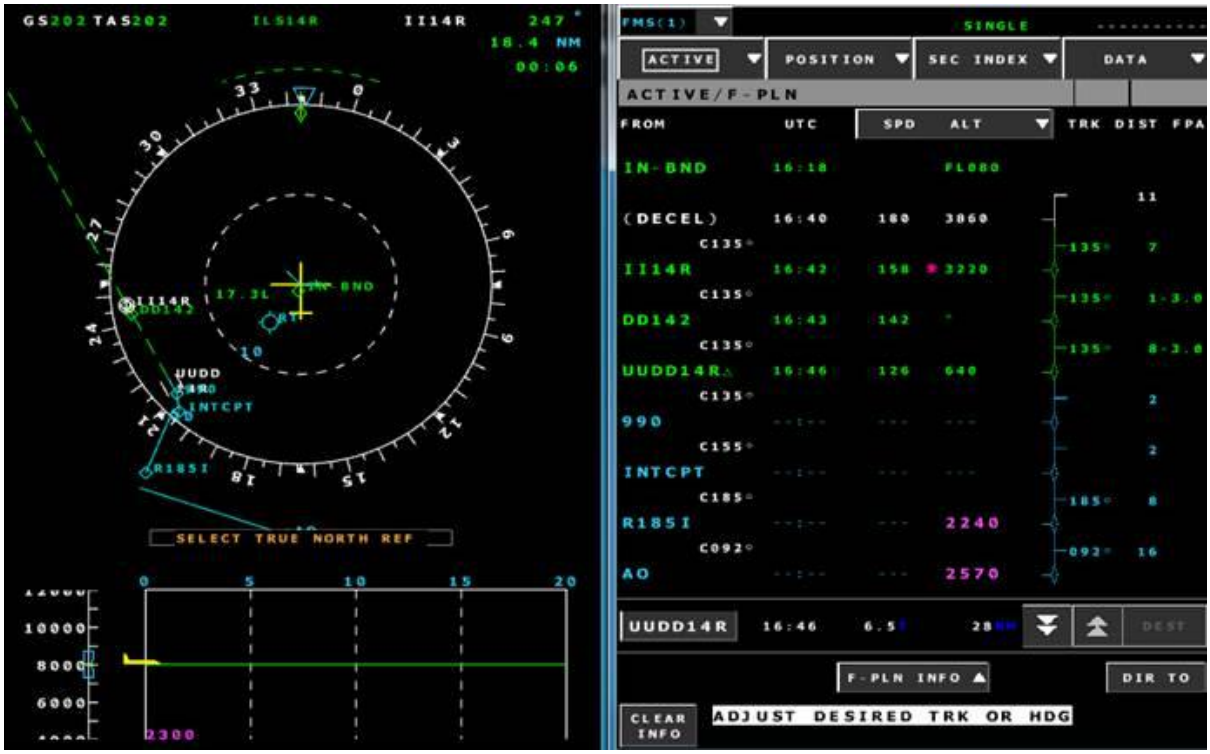

Figure A1.1 – Illustration of FMS flight plan displays on MFD and ND after selection of II14R waypoint using DIR TO CRS IN

The DIR TO CRS IN function was used to create a direct leg from the Aircraft present position to intercept an inbound course of II14R (IF) waypoint.

At 1746:21, the Aircraft reached 8,024 feet, and ALT was displayed on the FMA, which means that the altitude hold mode was engaged and held the 8,000 feet as selected on the AFS CP, and the altitude capture mode became disengaged (ALT* disappeared on FMA). 11 seconds later, the Aircraft reached and levelled off at 8,000 feet.

At 1746:24, HDG/TRK knob was pulled (it was actually not necessary since heading mode was already engaged) resulted in arming and then disarming again in one second of NAV mode.

At 1746:27, the indicated active waypoints were II14R on the FMS flight plan.

At 1746:35, ALT knob was rotated to change the selected altitude target from 8,000 to 7,000 feet. The Aircraft was levelling at 8,000 feet, and the airspeed was 180 knots. Thereafter, the ALT knob was pulled, which engaged open descent mode (OP DES appeared on FMA), and the altitude hold mode became disengaged (ALT disappeared on FMA). The altitude hold mode became armed (ALT displayed on the FMA). The autothrust managed the engines applying idle thrust. THR IDLE appeared and SPEED disappeared on the FMA.

Between 1746:38 and 1746:45, HDG knob was rotated to select the heading from 340 to 280 degrees, and consequently, the Aircraft started to turn left. At 1746:41, the Aircraft started to descent.

At 1747:22, the Aircraft stopped to turn and maintained at the selected heading of 280 degrees, while descending passing 7,236 feet and the airspeed was 181 knots.

At 1747:32, selected altitude target was set by rotating ALT knob from 7,000 to 6,000 feet, while the Aircraft was descending through 7,100 feet pressure altitude. The airspeed was 180 knots.

At 1747:54, while the Aircraft was descending through 6,716 ft, the Radar Controller informed the flight crew that expected radar vectors will be provided for the approach and landing on runway 14R. Radar Controller instructed to turn the Aircraft onto a heading of 240 degrees, speed 180 knots, and descend to 800 meters with QFE set at 994 (3,220 feet at QNH 1015), which then read back correctly by the Commander. The airspeed was already at the selected speed target of 180 knots.

Between 1748:01 and 1748:06, the HDG knob was rotated to set the selected heading to 240 from 280 degrees. The Aircraft was descending through 6,568 feet when HDG knob was rotated at the beginning. Consequently, the Aircraft started to turn left.

Between 1748:14 and 1748:17, the ALT knob was rotated to select the altitude target from 6,000 to 3,300 feet. The Aircraft was descending through 6,264 feet pressure altitude and still turning left through 265 degrees when ALT knob was rotated initially. The airspeed was approximately 180 knots. The altitude target was selected as instructed, 800 meters QFE (3,220 feet QNH). However, the altitude setting was rounded up to 3,300 feet, as a safety margin was applied by the flight crew.

At 1748:41, the Radar Controller provided clearance for the ILS runway 14R to the flight crew, and instructed EK131 to turn onto a heading of 230 degrees, speed 180 knots, and to descend to 800 meters QFE, which was read back correctly by the Commander.

Between 1748:45 and 1748:47, the HDG knob was rotated to set the selected heading to 230 from 240 degrees. The Aircraft was descending through 5,668 feet when the HDG knob was rotated initially. The Aircraft was maintaining a heading of 240 degrees, consequently, the Aircraft started to turn left after the 230 degrees setting.

At 1748:59, the Radar Controller instructed the flight crew to maintain an airspeed of 180 knots as long as possible, and was read back correctly by the Commander.

At 1749:08, the Aircraft stopped turning and maintained on the selected heading of 230 degrees, while descending through 5,010 feet pressure altitude.

At 1749:29, the Radar Controller instructed the flight crew to turn the Aircraft onto a heading of 220 degrees. The Commander acknowledged the instruction to take up a heading of 220 degrees. The Aircraft was descending through 4,892 feet.

At 1749:31, the HDG knob was rotated to 220 from 230 degrees, while the Aircraft was descending through 4,812 feet when HDG knob was rotated. The Aircraft started to turn left after the 220 degrees setting.

At 1749:54, the Aircraft stopped turning and maintained on the selected heading of 220 degrees, while descending through 4,452 feet pressure altitude.

At 1750:12, Radar Controller provided clearance to the flight crew for ILS runway 14R on a heading of 220 degrees to establish the localizer, and at an airspeed of 170 knots. The Commander then read back correctly.

At 1750:29, flaps lever position was set to configuration ‘2’. Hence, flaps started to move from 8º and reached 17º at 1750:37. The slats stayed at 20º.

Between 1750:29 and 1750:31, SPD knob was rotated to set the selected speed target from 180 to 170 knots, which consequently, the airspeed thereafter started to decrease. The Aircraft was descending through 3,852 feet pressure altitude (3,602 feet QFE).

At 1750:51, APPR pushbutton was pressed. AP1 on PRIM 1, 2, and 3 became engaged, and AP1+2 displayed on FMA. This means that both autopilot AP1 and AP2 were engaged, since AP2 was already engaged. Since both autopilots (APs) were engaged, AP1 became the active autopilot, and AP2 was on standby. The glideslope mode (G/S) and LOC

mode (LOC) became armed as displayed on FMA. FMS1 became the master for FMS guidance, while FMS2 as the slave.

At 1751:06, the airspeed reached 170 knots, while the Aircraft was descending through 3,464 feet pressure altitude.

At 1751:10, open descent mode became disengaged (OP DES disappeared on FMA), and the altitude capture mode (ALT*) was displayed on the FMA since the Aircraft reached the capture zone of the selected altitude of 3,330 feet. Therefore, the altitude hold mode became disarmed (ALT disappeared from the FMA).The Aircraft was descending through 3,404 feet. The autothrust managed the engines thrust to control the target speed. THR IDLE disappeared and SPEED appeared on the FMA.

17:51:11 II14R (IF) waypoint was sequenced by the FMS. The Aircraft pressure altitude was 3,388 feet, and the airspeed was 170 knots. The Aircraft was at a distance of about 6.8 nautical miles from the extended runway 14R centreline.

At 1751:15, the indicated active waypoints were DD142 on the FMS flight plan as displayed on the MFD and ND (figure A1.2 below).

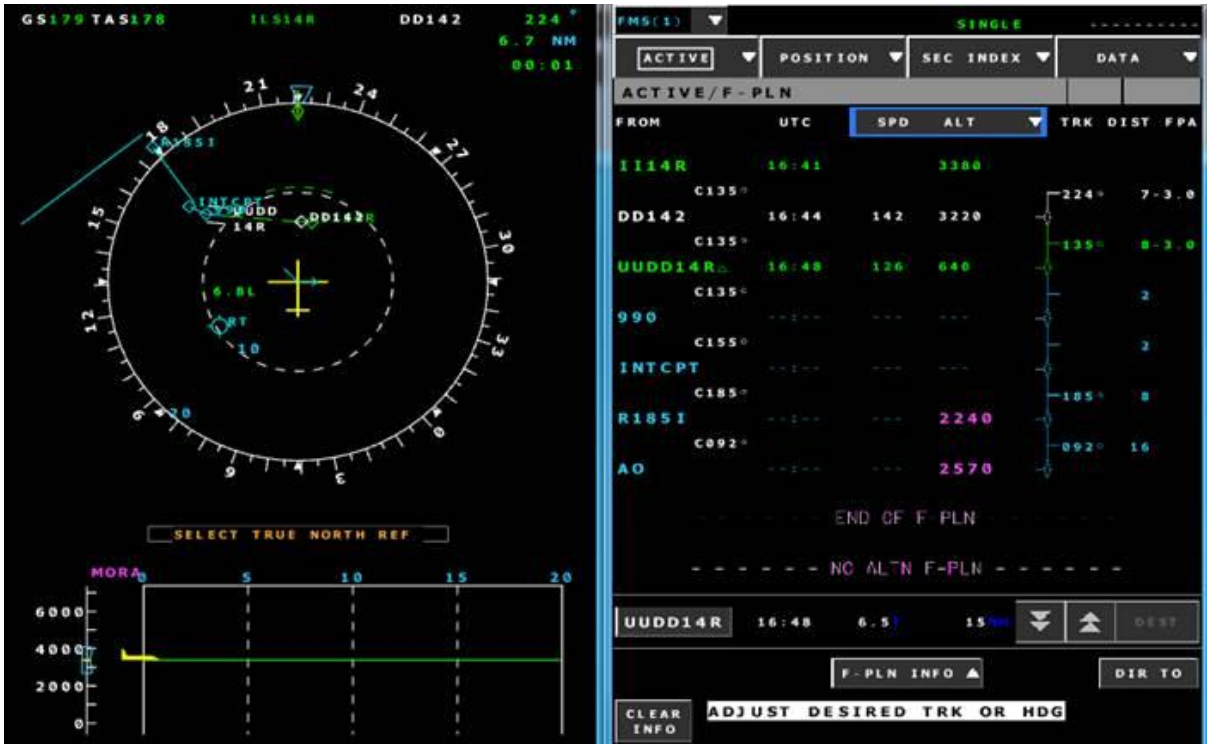

Figure A1.2 – Illustration of FMS flight plan displays on MFD and ND after II14R waypoint was sequenced

At 1751:17, the Aircraft reached 3,316 feet, and ALT was displayed on the FMA, which means that the altitude hold mode was engaged, since the Aircraft reached near the selected altitude of 3,300 feet. The altitude capture mode became disengaged (ALT* disappeared on FMA).

At 1751:30 ATC time, Radar Controller provided the flight crew a free choice to descend to 500 meters QFE (2,230 feet QNH) in order to establish the localizer. The Commander replied and informed the Controller that the Aircraft will descend to 500 meters to establish the localizer. At this time, the Aircraft was maintaining on heading 220 degrees, levelling at about 3,300 feet pressure altitude, and the airspeed was 169 knots.

Between 1751:38 and 1751:41, ALT knob was rotated to select the altitude target from 3,300 to 2,300 feet.

At 1751,41, Radar Controller acknowledged about the descent to 500 meters to establish ILS, and instructed the flight crew to maintain present heading and airspeed of 170 knots, as long as possible for separation with a traffic behind the Aircraft.

At 1751:42, ALT knob was pulled, which engaged open descent mode (OP DES vertical selected mode, appeared on FMA), and altitude hold mode became disengaged which resulted in disappearing of ALT on the FMA. The altitude hold mode became armed (ALT appeared on the FMA). The autothrust managed the engines applying idle thrust. THR IDLE appeared and SPEED disappeared on the FMA.

At 1751:47, the Aircraft started to descend to the selected altitude target of 2,300 feet.

At 1752:03, landing gear lever was set to DOWN position. The landing gear started to extend and reached full down locked position at 1752:17.

At 1752:06, Ground Spoiler was set to arm by pulling the SPEED BRAKE lever into the armed position.

At 1752:08 ATC time, Radar Controller informed the flight crew that there was no separation issue anymore. In addition, no speed limit was provided to the flight crew. The Commander then read back correctly. At this time, the Aircraft was heading on 220 degrees, descending through 3,016 feet pressure altitude, and the airspeed was 171 knots.

At 1752:09, DD142 (P) point was sequenced. The Aircraft was descending through 3,000 feet pressure altitude, and the airspeed was 170 knots.

Between 1752:11 and 1752:13, HDG knob was rotated from 220 to 212 degrees, while the Aircraft was descending through 2,964 feet when the HDG knob was rotated at the beginning.

Between 1752:15 and 1752:34, the glideslope deviation was stabilized and indicated average 1.9 (recorded data was around a mean value of +140 µA) above the IDM 3º ILS glideslope.

At 1752:15, the indicated active waypoints were UUDD14R as displayed on the FMS (figure A1.3).

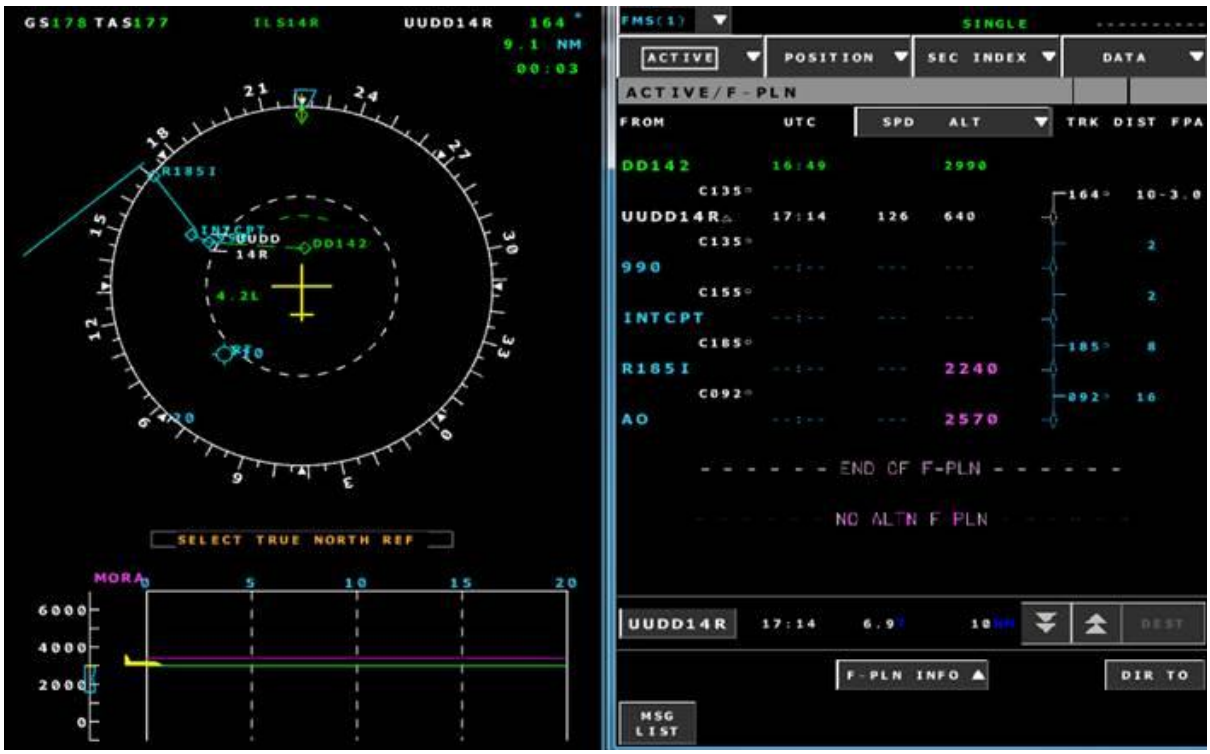

Figure A1.3 – Illustration of FMS flight plan displays on MFD and ND after DD142 waypoint was sequenced

The Aircraft started to turn left at 1752:16. The flaps lever position was set to configuration '3'. Hence, slats/flaps started to move from 20º/17º and reached 23º/26º at 1752:24.

At 1752:21, the ARC mode of the Co-pilot ND range was changed from 20 to 10 nautical miles.

At 1752:24, SPD knob was pushed, hence speed managed mode became engaged. The target speed changed from 170 to 143 knots. 143 knots was the target approach speed. Consequently, the airspeed started to reduce.

At 1752:30, all gears were down and in locked condition, started with the left and right wing gears, then nose gear, and last the left and right body gears, respectively.

At 1752:33, SPD knob was pulled, hence speed managed mode became disengaged. At this time, the Aircraft was descending through 2,560 feet and the airspeed was reducing through 162 knots.

Between 1752:33 and 1752:37, SPD knob was rotated to change selected speed target back to 170 knots. The airspeed continued reducing until reaching 158 knots, and at 1752:44, it started to increase to the selected speed target of 170 knots.

At 1752:40, open descent mode became disengaged (OP DES disappeared on FMA). The altitude capture mode became engaged, as indicated by the appearing of ALT* on the FMA since the Aircraft reached the capture zone of the (AFS CP) selected altitude of 2,300 feet. The Aircraft was descending through 2,472 feet. Therefore, the altitude hold mode became disarmed (ALT disappeared from the FMA). The autothrust managed the engines thrust to control the target speed. THR IDLE disappeared and SPEED appeared on the FMA.

At 1752:47, ALT knob was rotated changing from 2,300 to 3,000 feet, while the Aircraft was descending through 2,320 feet pressure altitude on heading 212 degrees. The airspeed was increasing through 159 knots. The altitude capture mode became disengaged,

as indicated by the disappearing of ALT* on the FMA, and the altitude hold mode became armed (ALT appeared on the FMA). The vertical mode reverted to vertical speed selected mode since selected altitude on AFS CP was set out of the capture zone as obtained previously (at 2,472 feet pressure altitude).

At 1752:48, V/S Knob was pulled to engage vertical speed selected mode. The altitude hold mode became disarmed (ALT disappeared on the FMA).

Between 1752:49 and 1752:50, V/S knob was rotated and set to -2,000 from -1,150 feet per minute (fpm); hence V/S-2000 appeared on FMA.

At 1752:51 ATC time, Radar Controller instructed the flight crew to maintain the present heading of 220 degrees in order to establish on the final approach point (P), and to continue descend to 500 meters. Radar Controller also instructed the flight crew to contact Tower control at 118.6 MHz and provided the QNH setting of 1015 mbar. At this time, the Aircraft was on heading 212 degrees, descending through 2,284 feet pressure altitude (1,787 feet radio height). The airspeed was 162 knots.

At 1752:55, HDG knob was rotated from 212 to 211 degrees, while the Aircraft was descending through 2,208 feet pressure altitude at this time. The airspeed was 164 knots.

At 1752:57, the glideslope deviation indication reached on profile, and thereafter continued descending below the ILS glideslope profile and it reached the two dots below the profile at 1753:05.5.

At 1752:59, the Aircraft started to turn left gradually in a small step. At this time, the Aircraft was descending through 2,104 feet pressure altitude (1,602 feet radio height), and the airspeed was 168 knots (it almost reached the selected speed target of 170 knots).

Between 1753:01 and 1753:03, HDG Knob was rotated. from 211 to 210 degrees, while the Aircraft was descending through 2,044 feet at the beginning of the HDG rotation.

Between 1753:03 and 1753:05, SPD knob was rotated from 170 to 160 knots. The airspeed reached 170 knots at the beginning of the knob rotation; however, it was still increasing.

At 1753:07, the Aircraft was descending passing 1,852 feet pressure altitude. The glideslope deviation reached about 2 dots (recorded data was -175 µA) below the IDM ILS glideslope (maximum display scale is 2 dots), and continued decreasing below the 2 dots.

At 1753:09, SPD knob was pushed by the Co-pilot, hence speed managed mode became engaged, and the target speed changed to 144 knots.

At 1753:11 ATC time, Radar Controller instructed the flight crew to obtain 500 meters height based on QFE 994 or QNH 1015, and to stop the descent further (3 times mentioned). Radar Controller informed the flight crew that at ATC screen, Aircraft's transponder indicated at 290 meters elevation and the runway elevation is 180 meters.

The Aircraft was maintaining on heading 210 degrees, descending through 1,720 feet pressure altitude (1,205 feet radio altitude), and the airspeed was 174 knots. The Radar Controller took approximately 17 seconds to transmit this instruction to the Aircraft.

At 1753:12, the flaps lever position was changed from configuration '3' to 'FULL', consequently the slats/flaps changed from 23º/26º to 23º/33º.

At the beginning of Radar control communication, the Aircraft was on a heading of 210 degrees, descending through 1,720 feet pressure altitude (1,205 feet radio altitude), and the airspeed was 174 knots. The selected vertical speed was at -2,000 fpm, while the selected pressure altitude was at 3,000 feet.

At 1753:19, HDG Knob was rotated from 210 to 188 degrees, while the Aircraft was descending through 1,468 feet pressure altitude (956 feet radio height).

At 1753:24, the Aircraft was descending passing 1,292 feet pressure altitude (747 feet radio altitude). The glideslope deviation reached about 3.3 dots (recorded data was -243 µA) below the IDM ILS glideslope. The localizer deviation was 3.6 dot (recorded data was +267 µA) with the Aircraft was on the left side of the localizer axis).

At 1753:25, ALT pushbutton was pressed, hence altitude hold mode engaged (ALT displayed on the FMA). Vertical speed selected mode became disengaged (V/S -2,000 disappeared on FMA). The Aircraft descended through 707 feet with a rate of descent approximately 2,000 feet per minute.

At 1753:26, ALT knob was rotated from 3,000 to 3,100 feet, and at the same time, the knob was pulled. The altitude hold mode became disengaged (ALT disappeared on the FMA). The open climb mode (OP CLB vertical selected mode) became engaged as indicated as OP CLB appearing on FMA. SPEED disappeared on the FMA.

The airspeed reached a maximum of 177 knots at 1753:26, and then it reduced.

Between 1753:27 and 1753:31, V/S knob was rotated from -2,000 to +2,500 fpm. At the beginning of the knob rotation (1753:27), the knob was also pulled which accordingly engaged the vertical speed (V/S) selected mode. The open climb mode (OP CLB vertical selected mode) became disengaged (OP CLB disappeared on FMA). SPEED appeared on the FMA. After the V/S knob rotation, V/S +2,500 appeared on FMA.

At 1753:30, the altitude hold mode became armed (ALT appeared on the FMA).

At 1753:31, TOGA was activated manually and engines thrust increased. At this time, the Aircraft was on heading 197, descending through 1,084 feet pressure altitude (504 feet radio altitude) with a rate of descent of 1,616 feet per minute, and the airspeed was 173 knots.

The glideslope deviation reached about 3.4 dots (recorded data was -253 µA) below the IDM ILS glideslope. The localizer deviation was 3.4 dot (recorded data was +250 µA) with the Aircraft was on the left side of the localizer axis).

The flight crew set the thrust levers at TOGA detent. MAN TOGA appeared on the FMA. Hence, A/THR was armed by setting the thrust levers at TOGA detent and engaged a go-around (MAN TOGA).

The autothrust managed the engines thrust to apply climb thrust for 1 second only. SPEED disappeared on the FMA. THR CLB appeared for 1 second and disappeared on the FMA. Autothrust (A/THR) became disengaged and armed.

At the same time of TOGA activation, the Commander informed Radar Controller that the Aircraft was performing a go-around. The flight phase of the FMS switched to go-around phase.

The figure A1.4 below illustrates the Aircraft position versus approach path at the time of go-around activation.

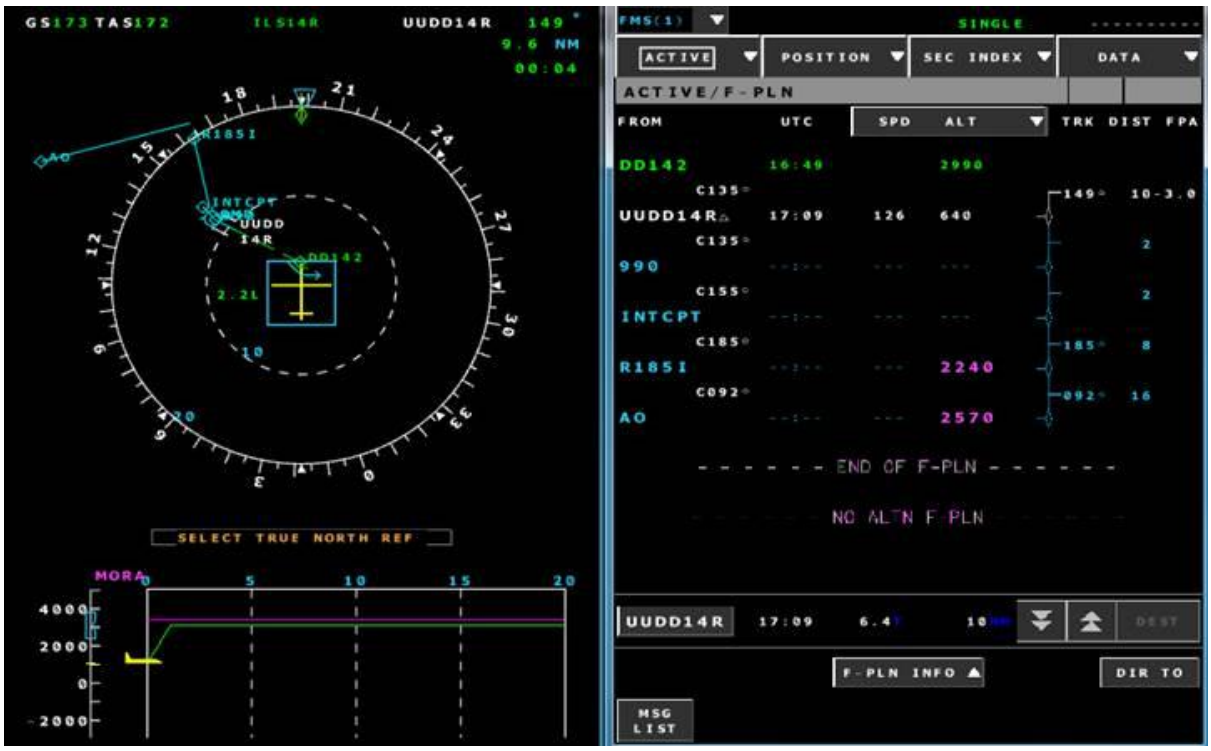

Figure A1.4 – Illustration of FMS flight plan displays on MFD and ND at the time of go-around activation

The previous ILS 14R approach was automatically re-strung into the FMS flight plan on the go-around flight phase as shown in figure A1.5 below).

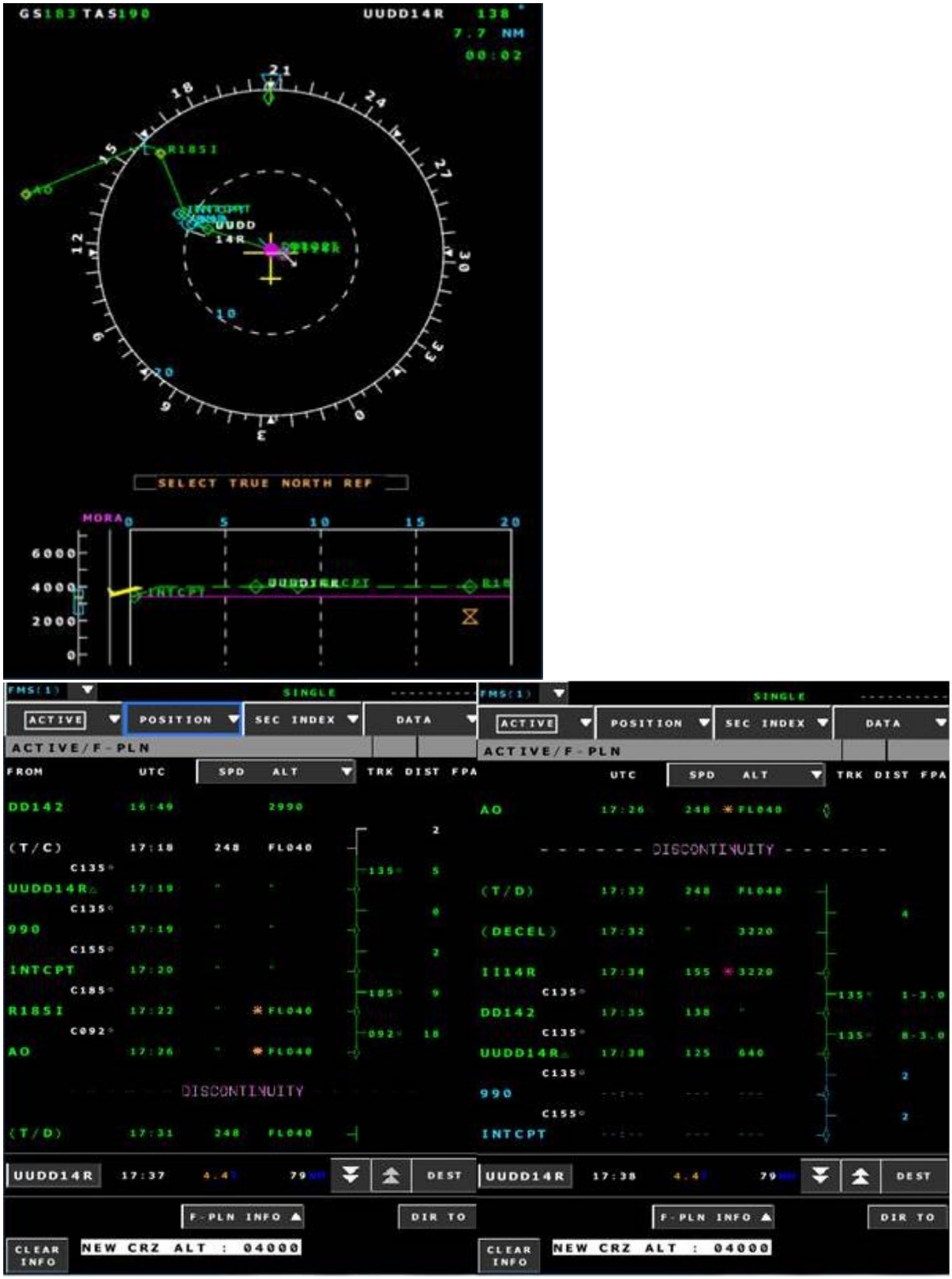

Figure A1.5 – Illustration of FMS flight plan displays on MFD and ND when previous ILS 14R approach was automatically re-strung into the FMS flight plan on go-around flight phase

At 1753:32, the glideslope mode (G/S) and LOC mode (LOC) became disarmed as indicated with the disappearing of G/S and LOC on the FMA. The vertical speed selected mode (V/S), and heading selected mode (HDG) became disengaged (V/S and HDG

disappeared on FMA). NAV mode became engaged (NAV appeared on FMA). The speed reference system managed mode (SRS) also became engaged as indicated with the appearance of SRS on the FMA.

Based on the FMS BITE data, the go-around phase was activated in the FMS. As per design, the ILS 14R missed approach was active in the flight plan, separated by a discontinuity with the ILS 14R approach automatically re-strung.

At 1753:33, glideslope alerts appeared. At this time, the Aircraft was on heading 197 degrees, descending through 1,048 feet pressure altitude (474 feet radio height), and the airspeed was 172 knots. The alerts appeared for approximately 2 seconds with a “Glideslope” aural alert, and GLIDE SLOPE visual alert appeared on the PFD.

The minimum radio altitude/height reached 395 feet during the alerts appearance, occurred at 1753:34.

At 1753:35, the localizer deviation was 4.8 dot (recorded data was +220 µA) with the Aircraft was on the left side of the localizer axis).

At the same time, “Terrain ahead, pull up” aural warning and TERRAIN visual alert on both NDs for 6 seconds; and lasted in one second of another “glideslope” aural alert and GLIDE SLOPE visual alert appeared on the PFD at 1753:41.

Also at same time, Radar Controller instructed the flight crew to continue on the present heading of 200 degrees, which then replied correctly by the Commander. The Aircraft was climbing through 1,028 feet pressure altitude (420 feet radio height) and on heading 193 degrees while still turning left. The distance between the Aircraft and runway 14R threshold was about 7.5 nautical miles (7.4 nautical miles IDM DME).

At this time, the thrust levers were moved back to FLX-MCT detent, which became a soft go-around, and MAN GA SOFT appeared on the FMA. This thrust setting controlled the engines applying thrust to target the vertical speed of approximately +2,000 fpm.

Four seconds later, the thrust levers were moved back to FLEX MCT detent, which became the soft go-around, and MAN GA SOFT appeared on the FMA.

At 1753:36, the altitude hold mode became disarmed (ALT disappeared on the FMA) since speed reference system managed mode was engaged, and the AFS CP selected altitude (3,100 feet) was above the acceleration altitude[25] (2,400 feet).

The climb managed mode (CLB mode) became armed (CLB appeared on the FMA), since speed reference system managed mode and navigation managed mode were engaged, and the acceleration altitude was available and below the AFS CP selected altitude (3,100 feet).

At 1753:45, HDG Knob was pulled, which engaged the heading selected mode as indicated with the appearing of HDG on FMA. The navigation mode became disengaged (NAV disappeared on FMA), hence, the climb managed mode disarmed (CLB disappeared on the FMA). The open climb selected mode became armed (OP CLB appeared on FMA) since speed reference system managed mode was engaged (SRS), and navigation managed mode was neither armed nor engaged.

The flaps lever position was changed from configuration ‘FULL’ to ‘3’, consequently the slats/flaps changed from 23º/33º to 23º/26º.

Between 1753:46 and 1753:48, HDG knob was rotated to 200 degrees, while the Aircraft was climbing through 1,280 feet pressure altitude (736 feet radio height), and the

[25] The altitude at which the aircraft accelerates towards the initial climb speed.

airspeed was 169 knots at the beginning of the setting (at 1753:46). The target speed was 159 knots.

At 1753:49, Radar Controller instructed the flight crew to climb to 900 meters QFE (3,550 feet QNH) and to maintain that altitude on a heading of 200 degrees, which then read back correctly by the Commander.

At 1753:53, ALT knob was rotated from 3,100 to 2,400 feet. The open climb selected mode became disarmed (OP CLB disappeared on FMA), since acceleration altitude became equal to the AFS CP selected altitude (2,400 feet). The Aircraft was climbing through 1,556 feet pressure altitude. The altitude hold mode became armed (ALT appeared on the FMA), since speed reference system managed mode was engaged and the next altitude target was 2,400 feet as the AFS CP selected altitude.

At 1753:55, LVR CLB flashed, means that the Aircraft reached the thrust reduction altitude, and a request to set the thrust levers to the CL detent. The Aircraft was climbing passing 1,628 feet pressure altitude.

The flashing occurred about 15 seconds until the thrust levers were set to CL detent.

Between 1753:56 and 1753:57, ALT knob was rotated from 2,400 to 3,200 feet. The altitude hold mode became disarmed (ALT disappeared on the FMA) since the AFS CP selected altitude, 3,200 feet, was above the acceleration altitude of 2,400 feet pressure altitude, and speed reference system managed mode was still engaged. Hence, the open climb selected mode became armed (OP CLB appeared on FMA).

Between 1753:59 and 1754:01, ALT knob was rotated from 3,200 to 3,600 feet. The Aircraft was climbing through 1,760 feet pressure altitude (1,243 feet radio altitude), and the airspeed was 159 knots, at the beginning of the knob rotation.

At 1754:07, landing gear lever was set to UP position. Hence, all gears started to retract, and reached full up and locked position at 1754:25.

From the time that the go-around was performed (17:53:35) until 1754:09, autothrust flex (soft) go-around was set.

At 1754:10, autothrust disarmed and engaged automatically (ALT disappeared and A/THR appeared on the FMA). MAN GA SOFT disappeared and THR CLB appears on FMA, which means that the thrust levers were set to CL detent.

At 1754:13, Radar Controller instructed the flight crew to climb and maintain 900 meters on heading 180 degrees. The Commander then read back correctly.

Between 1754:21 and 1754:24, HDG Knob was rotated from 200 to 180 degrees. At the beginning of the knob rotation, the Aircraft was climbing through 2,328 feet pressure altitude (1,931 feet radio altitude), and just reached a magnetic heading of 200 degrees. The airspeed was 160 knots.

At 1754:25, the FMS switched to CLIMB phase. AP 2 was disengaged, while AP1 still engaged. Hence, AP1+2 disappeared, and AP1 appeared on FMA. Speed reference system managed mode (SRS mode) became disengaged (SRS disappeared on FMA) since open climb selected mode became engaged from armed condition (OP CLB appeared and OP CLB disappeared on FMA). This means that the Aircraft reached the go-around (GA) acceleration altitude. GA acceleration altitude displayed on the G.A panel of the FMS PERF page. The altitude hold mode became armed (ALT appeared on the FMA) since OP CLB became engaged, and the AFS CP selected altitude was not set to the cruise altitude. The Aircraft was climbing passing 2,448 feet. AP2 became disengaged since both APs were engaged in SRS go-around, and SRS became disengaged.

At 1754:26, Radar Controller questioned the flight crew about reason of the go-around. The Commander then answered that unstable approach was the reason.

At 1754:41, Radar Controller instructed the flight crew to climb the Aircraft to 900 meters on a heading of 180 degrees, which then read back correctly by the Commander.

At 1754:46, SPD knob was pulled and rotated, which engaged the speed selected mode, and disengaged speed managed mode. The SPD knob was rotated between 1754:46 and 1754:50, and finally it was set to 189 knots.

At 1754:52, the flaps lever position was moved from configuration '3' to '1'. Hence, slats/flaps started to move from 23º/26º. The slats reached 20º at 1754:59, while the flaps reached 8º at 1755:04.

At 1754:55, the Aircraft was climbing through 3,216 feet pressure altitude (2,824 feet radio altitude), and the airspeed was 190 knots. The altitude capture mode became engaged and altitude hold mode became disarmed (ALT* displayed and ALT disappeared on the FMA), since the Aircraft reached the capture zone of the selected altitude of 3,600 feet. Hence, open climb selected mode became disengaged (OP CLB disappeared on FMA), and the autothrust of speed mode became engaged (SPEED appeared on FMA) due to the change in the vertical mode from open climb selected mode to altitude acquire selected mode.

At 1755:12, altitude hold mode became engaged (ALT displayed on the FMA), and altitude capture mode became disengaged (ALT* disappeared on the FMA). The Aircraft was climbing through 3,584 feet pressure altitude (3,183 feet radio height), and the airspeed was 194 knots.

At 1755:16, the Aircraft reached 3,600 feet pressure altitude, and levelled off at that altitude.

At 1755:26, the flaps lever position was moved from '1' to '0'. Hence, slats/flaps started to move from 20º/8º. The flaps reached 0º at 1755:53, and the slats reached 0º at 1756:03.

Between 1755:29 and 1755:31, SPD knob was rotated from 189 to 201 knots. The airspeed was 189 knots, and it started to increase to the selected target speed of 201 knots.

Between 1755:32 and 1753:35, HDG knob was rotated from 180 to 200 degrees. Then, between 1755:36 and 1755:39, HDG knob was rotated to 180 degrees. The HDG knob changed from 180 to 200 degrees was not instructed for the Aircraft, but for other aircraft. That was why the HDG knob was rotated back to 180 degrees to maintain a heading of 180 degrees as instructed by Radar control.

At 1756:08, Ground Spoiler was disarmed.

At 1756:46, According to the FMS BITE data, The approach phase was activated on FMS by selecting and confirming the ACTIVATE APPR * prompt displayed on the MFD PERF page.

Between 1756:49 and 1756:50, SPD knob was rotated from 201 to 200 knots. The Aircraft was maintaining level at 3,600 feet pressure altitude (3,125 feet radio altitude), and the airspeed was 200 knots.

At 1757:06, Radar instructed the flight crew to turn the Aircraft onto a heading of 140 degrees, which then read back correctly by the Commander.

At 1757:07, the indicated active waypoints were INTCPT on the FMS flight plan.

Between 1757:10 and 1757:13, HDG knob was rotated from 200 to 140 degrees. Hence, the Aircraft started to turn left and the airspeed was maintaining at 200 knots.

At 1757:27, a lateral revision of the flight plan was performed on the Commander side by inserting II14R waypoint using the DIR TO CRS IN function

According to the report from the Aircraft manufacturer and the FMS manufacturer/supplier, the supplier performed a desktop simulation. From the simulation, a partial reconstruction of the ND and the MFD flight plan pages based on the recorded data of FMS1 BITE was provided as shown in the figure A1.6.

The figure A1.6 below illustrates the displayed FMS on the ND and MFD of both side (Commander and Co-pilot side), after selection of II14R waypoint using DIR TO CRS IN.

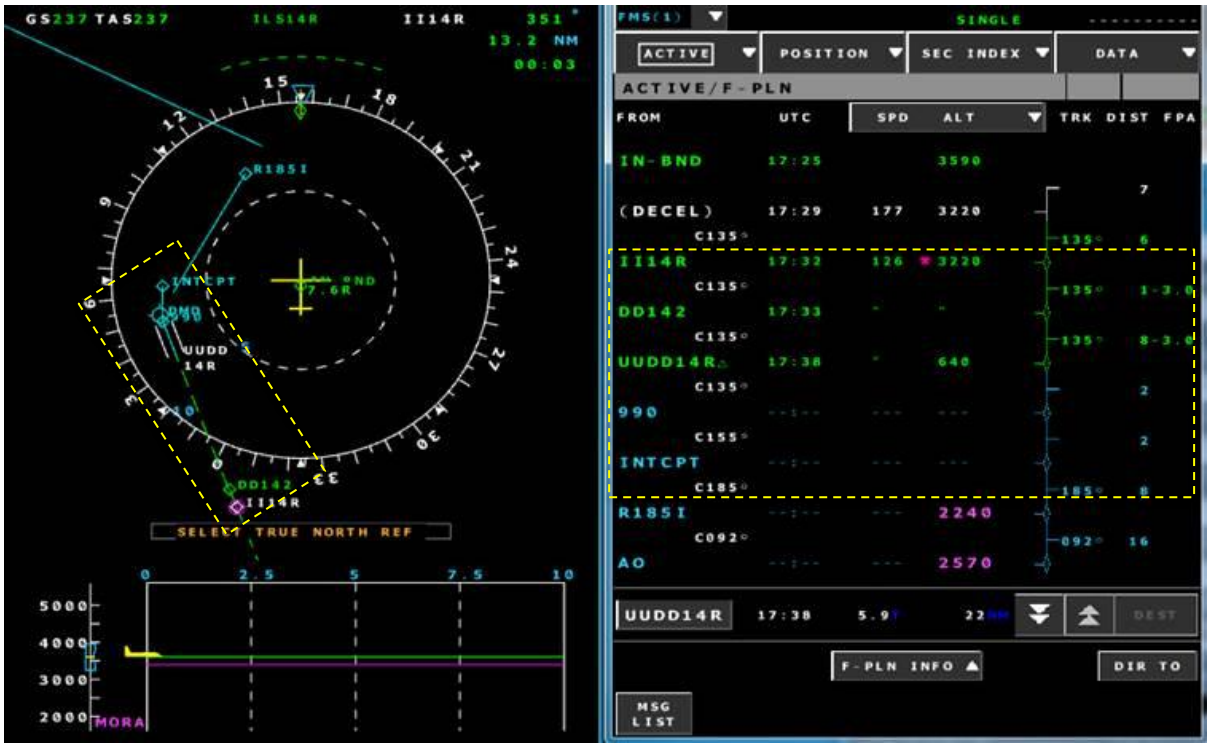

Figure A1.6 – Illustration of FMS flight plan displays on MFD and ND after selection of II14R waypoint using DIR TO CRS IN

At the time of DIR TO CRS IN function was performed, the Aircraft cross track position was more than seven nautical miles.

At 1757:30, HDG knob was pulled (it was actually not necessary since the HDG mode was already engaged). NAV became armed for 1 sec and became disarmed again.

At 1757:31, the indicated active waypoints were II14R on the FMS.

At 1757:45, the Aircraft reached and maintained the selected heading of 140 degrees and the airspeed was 200 knots.

At 1758:33, LS pushbuttons on both sides were OFF, therefore, the localizer and glideslope deviations did not display on the PFD.

Second Approach of ILS 14R and Go-around

At 1758:47, the Commander questioned Radar Controller of what would be the further instruction. The Radar replied that radar vector is expected to be provided, and instructed the flight crew to turn the Aircraft onto a heading of 100 degrees due to traffic. The Commander acknowledgement of the provided heading of 100 degrees, and requested for a longer final approach. The Radar Controller agreed the Commander's request.

Between 1758:57 and 1759:00, HDG knob was rotated from 140 to 100 degrees. Accordingly, the Aircraft started to turn left.

At 1759:36, the Aircraft reached and maintained heading 100 degrees. The airspeed was 200 knots, and the Aircraft was still maintaining at 3,600 feet pressure altitude (3,112 feet radio height).

Between 1759:37 and 1759:49, according to FMS BITE data, five waypoints of the flight plan (II14R, DD142, UUDD14R, 990 and INTCPT) were sequenced in a row, followed by a single auto-reset on the FMS1 (Commander side). FMS 1 was the guidance master at that time. The active waypoint became R185I (see figure A2.3). The R185I was the missed approach turning point to join the hold pattern anchored to AO waypoint. The FMS1 single auto-reset was also recorded on the PFR at 17:59 UTC (see Appendix 4).

The figure A1.7 below illustrates the displayed FMS flight plan on the ND and MFD after the multi-waypoint sequencing on the Co-pilot side, and after FMS 1 (FMC-A) recovery on the Commander side.

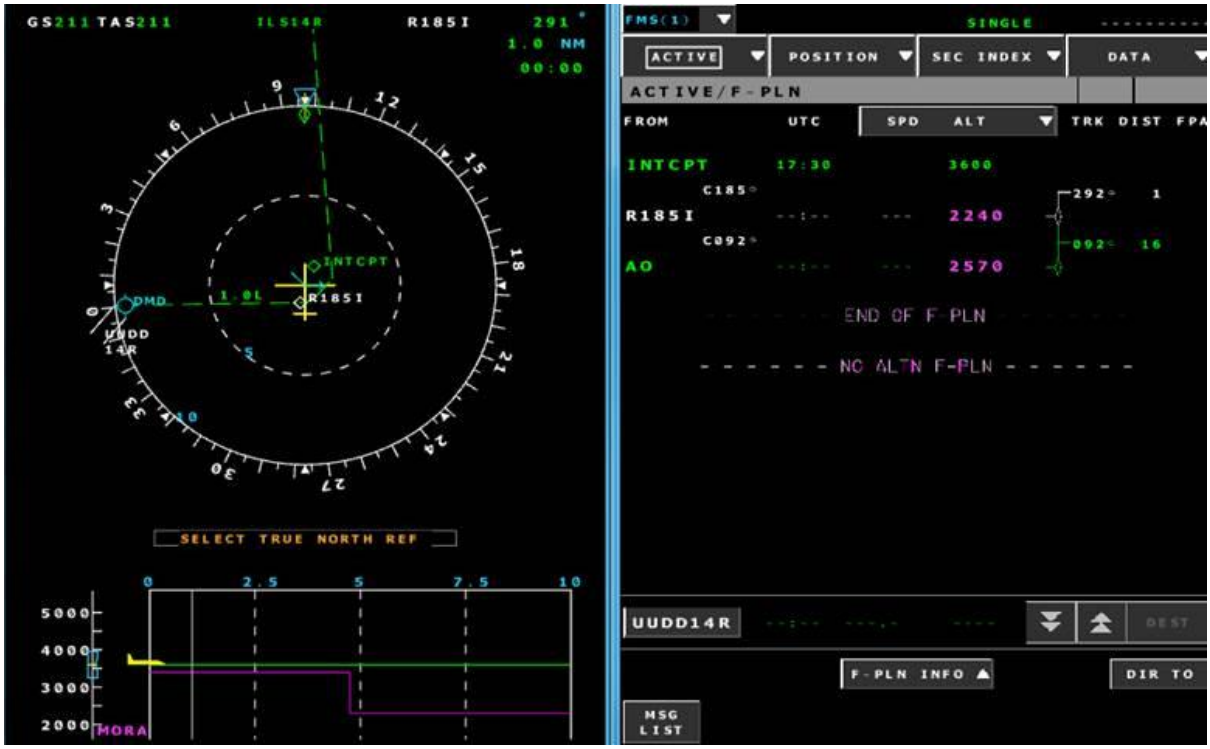

Figure A1.7 – Illustration of FMS flight plan displays on MFD and ND after multi-waypoint sequencing on Co-pilot side and after FMS 1 (FMC-A) recovery on Commander side

At 1759:51, the indicated active waypoints were AO and AO on the FMS.

At 1800:09, According to FMS BITE data, dual FMS operation was recovered, and this was 32 seconds after the single FMS1 auto-reset (about 20 seconds after the last / fifth waypoint sequence). During this period, 'MAP NOT AVAIL' and 'FMS PAGE NOT AVAIL' messages are displayed on the ND and MFD, respectively, on the Commander's side only.

At 1802:15, Radar Controller instructed the flight crew to turn the Aircraft onto a heading of 040 degrees. The Commander then read back correctly.

Between 1802:20 and 1802:23, HDG knob was rotated from 100 to 040 degrees. Accordingly, the Aircraft started to turn left.

At 1802:21, Radar Controller instructed the flight crew to maintain 900 meters height, and provided discretion for the airspeed, which then read back correctly by the Commander.

Between 1802:29 and 1802:33, SPD knob was rotated from 200 to 220 knots. Accordingly, the airspeed started to increased. At the beginning of the knob rotation, the Aircraft was turning left through heading 96 degrees.

At 1803:15, the airspeed reached 220 knots and maintained.

At 1803:28, Radar Controller instructed the flight crew to turn to heading 360 degrees. The Commander read back correctly.

Between 1803:35 and 1803:39, HDG knob was rotated from 040 to 360 degrees.

At 1804:10, the Aircraft reached and maintained heading 360 degrees.

At 1804:21, the LS pushbuttons on both sides side were activated, therefore, the localizer and glideslope deviations appeared on the PFD when the signals were available.

At 1804:38, Radar Controller instructed the flight crew to turn to heading 315 degrees, which then replied correctly by the Commander.

Between 1804:40 and 1804:43, HDG knob was rotated from 360 to 315 degrees. Accordingly, the Aircraft started to turn left.

At 1804:49, the LS pushbutton on both sides side were OFF, therefore, the localizer and glideslope deviations did bot display on the PFD.

At 1805:17, the LS pushbuttons on both sides side were activated, therefore, the localizer and glideslope deviations appeared on the PFD when signals were available.

At 1805:19, the Aircraft reached heading 360 degrees. Radar Controller instructed the flight crew to turn the Aircraft to heading 310 degrees, which then read back correctly by the Commander.

Between 1805:22 and 1805:23, HDG knob was rotated from 315 to 310 degrees. Accordingly, the Aircraft started to turn left.

At 1805:23, Radar Controller instructed the flight crew to descend the Aircraft to 800 meters and maintain that height, which then correctly read back by the Commander.

Between 1805:30 and 1805:31, ALT Knob was rotated from 3,600 to 3,300 feet.

Between 1805:31 and 0805:35, V/S Knob was rotated to -500 fpm and pulled, which engaged vertical speed selected mode (V/S-500 appeared on FMA). Hence, the altitude hold mode became disengaged (ALT disappeared on the FMA), and the altitude hold mode became armed (ALT appeared on the FMA). Thereafter, the Aircraft started to descend.

At 1805:42, the Aircraft reached the selected heading of 310 degrees and maintained on that heading.

At 1806:07, the Aircraft was descending through 3,380 feet pressure altitude (3,006 feet radio altitude), and the airspeed was 220 knots. The altitude capture mode became engaged (ALT* appeared on FMA) and the altitude hold mode became disarmed (ALT disappeared on FMA) since the Aircraft reached the capture zone of the selected altitude of 3,200 feet. Hence, the vertical speed selected mode became disengaged (V/S-500 disappeared on FMA).

At 1806:10, Radar Controller queried the flight crew to report the indicated airspeed. The Commander reported that the airspeed is 220 knots.

At 1806:14, due to traffic, Radar Controller queried whether the Aircraft would be able to have an airspeed of 200 knots. The Commander replied and informed that 200 knots could be obtained.

At 1806:15, altitude hold mode became engaged (ALT displayed on the FMA), and altitude capture mode became disengaged (ALT* disappeared on the FMA). The Aircraft was descending through 3,324 feet pressure altitude (2,954 feet radio height).

Between 1806:19 and 1806:22, SPD Knob was rotated from 220 knots to 200 knots. Accordingly, the airspeed started to decrease.

At 1806:25, the Aircraft reached at 3,288 feet pressure altitude (2,866 feet radio altitude), and levelling off at that altitude.

At 1807:03, the airspeed reached 200 knots and maintained thereafter.

At 1809:31, Radar Controller instructed the flight crew to reduce airspeed to 180 knots on present heading of 310 degrees, which then correctly read back by the Commander.

At 1809:40, flaps lever position was set to configuration '1'. Hence, slats/flaps started to move from 0º/0º. The flaps reached 8º at 1810:07, while the slats reached 20º at 1810:17.

Between 1809:41 and 1809:44, SPD knob was rotated from 200 to 187 knots, which the airspeed then started to decrease.

Between 1809:50 and 1809:52, SPD knob was rotated from 187 to 180 knots.

At 1810:11, the airspeed reached 180 knots and maintained thereafter.

At 1810:46, Radar control provided no speed limit to the flight crew. The Commander read back correctly.

At 1811:10, Radar Controller instructed the flight crew to turn left onto a heading of 230 degrees. The commander queried if the Aircraft could maintain heading for some nautical miles. However, Radar Controller informed that four nautical miles ahead the Aircraft was a prohibited area. Hence, the Commander agreed to turn left the Aircraft to 230 degrees.

At 1811:37 and 1811:46, HDG knob was rotated from 310 to 220 degrees. Accordingly, the Aircraft started to turn left.

At 1811:42, Radar Controller instructed the flight crew to turn the Aircraft onto a heading of 220 degrees and provided clearance to establish ILS runway 14R. The Commander then read back correctly.

At 1811:55, Radar Controller asked the flight crew whether the flight have any problems, which then replied 'negative' by the Commander.

At 1812:02, Radar Controller provided discretion for the airspeed and instructed to turn to heading 210 to establish cleared ILS runway 14R, which correctly read back by the Commander.

Between 1812:09 and 1812:10, HDG knob was rotated from 220 to 210 degrees. The Aircraft was turning left through heading 250 degrees at the beginning of knob rotation.

At 1812:12, APPR push button was pressed which enabled the Aircraft to fly ILS runway 14R approach. The glideslope mode (G/S) and LOC mode (LOC) became armed as displayed on FMA.

The localizer mode became armed since heading mode was already in an engagement condition (HDG).

The localizer mode and glideslope mode became armed, which means that at least one ILS receiver was operative. In addition, at least one radio altimeter was operative. From the two available radio altitude parameters of the FDR, both radio altimeters were operative.

At 1812:13, AP2 push button was pressed, hence AP2 on PRIM 1, 2, and 3 became engaged. AP1+2 appeared and AP1 disappeared on FMA, which means that both autopilot

AP1 and AP2 were engaged, since AP1 was already engaged. Since both autopilots (APs) were engaged, AP1 was still the active one, and AP2 was on standby.

At 1812:24, the Commander queried Radar Controller to have a lower altitude; however, Radar Controller replied and informed the flight crew that the height should be 800 meters on final as per standard procedure.

At 1812:35, SPD knob was pushed, which engaged the speed managed mode. Accordingly, the target speed became 140 knots, also as the target approach speed.

At 1812:36, the Aircraft reached heading 210 degrees, and maintained that heading.

At 1812:42, the Commander queried Radar Controller to repeat the message.

At 1812:43, flaps lever position was set to configuration '2'. Hence, flaps started to move from 8º and reached 17º at 1812:51. The slats stayed at 20º.

At 1812:45, Radar Controller repeated the instruction of 800 meters on final, and additionally instructed to turn the Aircraft onto a heading of 220 degrees to establish the ILS. Subsequently, the Commander replied correctly.

Between 1812:56 and 1812:59, HDG Knob was rotated from 210 to 220 degrees and the Aircraft started to turn to the right.

At 1813:00, Radar Controller informed that the Aircraft is at 800 meters according to Radar control's monitor. The Commander replied that the Aircraft would comply maintaining 800 meters.

At 1813:10, landing gear lever was set to DOWN position. Hence, all gears started to extend and reached full down position at 1813:25.

At 1813:14, Ground Spoiler became armed. The flaps lever position was set to configuration '3'. Hence, slats/flaps started to move from 20º/17º and reached 23º/26º at 1813:21.

At 1813:19, Radar Controller questioned whether the flight crew was ready to continue approach. The Commander replied and mentioned that the Aircraft was ready to continue the approach.

At 1813:20, the Aircraft reached heading 220 degrees, and maintained that magnetic heading.

At 1813:31, Radar Controller again informed the flight crew about the ILS runway 14R clearance on heading 220 degrees for the establishment. Additionally, no restriction of speed and traffic on final with 10 kilometers distance from the Aircraft were informed. At this time, the Aircraft was maintaining level at about 3,280 feet pressure altitude (800 meters radio altitude) on heading 220 degrees.

At 1813:44, the flaps lever position was set to configuration 'FULL'. Hence, slats/flaps started to move from 23º/26º, and reached 23º/33º at 1813:52.

At 1814:02, Radar Controller questioned the flight crew whether they were ready to turn left the Aircraft in order to establish the localizer. The Commander replied and mentioned that the Aircraft was ready to turn left.

At 1814:08, Radar Controller instructed the flight crew to turn left to establish localizer and to contact Tower control on 118.6 MHz. No restriction of speed and no separation issue information were also given to the Aircraft.

Between 1814:11 and 1814:13, HDG knob was rotated from 220 to 190 degrees. Accordingly, the Aircraft started to turn left.

At 1814:13, the airspeed was decreasing through 140 knots, and maintaining level at 3,292 feet pressure altitude. The target speed was 139 knots, also as the target approach speed.

At 1814:35, LOC pushbutton was pressed, hence the glideslope mode became disarmed as indicated by disappearing of G/S on FMA. AP2 on PRIM 1, 2, and 3 became disengaged, while AP1 still engaged. Hence, AP1+2 disappeared, and AP1 appeared on FMA.

Between 1814:36 and 1814:38, HDG knob was rotated from 190 to 180 degrees, when the Aircraft was turning left and almost reached 190 degrees heading.

At 1814:37, the airspeed reached 139 knots, which was the same as the target approach speed.

At 1814:44, APPR push button was pressed, hence the glideslope mode became armed as indicated by displaying G/S on FMA.

At 1814:45, AP2 push button was pressed, hence AP2 on PRIM 1, 2 and 3 became engaged. AP1+2 appeared and AP1 disappeared on FMA, which means that both autopilot AP1 and AP2 were engaged, since AP1 was already engaged. AP1 was the active one, and AP2 was on standby.

At 1814:47, the Commander radioed Domodedovo Tower control. The Aircraft was turning left through heading 184 degrees and maintaining approximately 800 meters height. The airspeed maintained at about 139 knots.

At 1814:50, Tower Controller replied and instructed the Aircraft to continue approach, which then read back the instruction correctly by the Commander.

At 1814:56, the Aircraft reached heading 180 degrees and maintained that heading thereafter. The airspeed was 138 knots, and the pressure altitude maintained level at 3,296 feet.

At 1815:09, localizer capture mode became engaged (LOC* displayed on FMA) by the automatic flight system (AFS) and the localizer mode became disengaged (LOC disappeared on the FMA.) since the Aircraft reached the capture zone, or the pre-capture zone of the LOC beam. The localizer deviation was 0.8 dot (recorded data was +63 µA) with the Aircraft was on the left side of the localizer axis.

The localizer interception angle was 42º, which equal to the Aircraft track angle (177º) subtracted by the inbound course of ILS 14R (135º). The wind direction was 222º with a speed of 11 knots. The headwind component was 9 knots, and crosswind component was 6 knots from the right side (based on the Aircraft true heading).

Heading mode became disengaged (HDG disappeared on FMA) since another lateral mode (localizer capture mode) engaged.

Between 1815:10 and 1815:11, HDG knob was rotated from180 to 166 degrees. The Aircraft then started to turn left.

At 1815:19, the Aircraft was still turning left through heading of 166 degrees, and the turning continued. Selected heading on the AFS CP remained 166 degrees.

At 1815:22, the maximum left bank angle of 27º was reached on the first LOC (localizer) overshoot.

At 1815:23, the glide slope capture mode became engaged (G/S* appeared on FMA) and the glideslope mode became disarmed (G/S disappeared on FMA) since the Aircraft

reached the capture zone of the glideslope (G/S) beam. Consequently, the altitude hold mode became disengaged (ALT disappeared on the FMA).

At 1815:24, the Aircraft started to descend, followed the altitude target used by AP. The Aircraft was still turning left, and the airspeed maintained at 139 knots.

At 1815:26, on the first LOC overshoot, the maximum localizer deviation was 1.3 dot (recorded data was -100 µA) with the Aircraft was on the right side of the localizer axis.

Between 1815:31 and 1815:33, ALT Knob was rotated from 3,300 to 2,600 feet. The Aircraft was descending through 3,260 feet pressure altitude (2,774 feet radio height), still turning left through heading 126 degrees, at the beginning of the knob rotation.

At 1815:39, glide slope track mode (G/S mode) became engaged (G/S appeared on FMA) and glide slope capture mode became disengaged (G/S* disappeared on FMA) since the Aircraft became established on the glideslope (G/S) beam.

At this time, the Aircraft was descending through 3,184 feet, followed the altitude target used by AP, which was descending gradually.

The heading was on 119 degrees. The selected heading on AFS CP remained at 166 degrees.

At 1815:54, the maximum right bank angle of 16º was reached on the second LOC overshoot.

At 1815:55, on the second LOC overshoot, the maximum localizer deviation was 0.65 dot (recorded data was +48 µA) with the Aircraft was on the left side of the localizer axis.

At 1816:18, the maximum left bank angle of 16º was reached on the third LOC overshoot.

The maximum localizer deviation was 0.7 dot (recorded data was -50 µA) with the Aircraft was on the right side of the localizer axis.

At 1816:31, UUDD14R waypoint was inserted using DIR TO function, which created a direct leg between the Aircraft present position and runway 14R threshold.

At 1816:32, the navigation managed mode became engaged (NAV appeared on FMA) since the flight crew selected UUDD14R waypoint using DIR TO function in the active flight plan on the MFD, with the condition of LOC* engagement and the Aircraft was above than 700 feet radio height, before using the DIR TO function.

At this time, the Aircraft was descending passing 2,612 feet pressure altitude (2,220 feet radio height) and at a distance of 6.5 nautical miles from runway 14R threshold. The airspeed was 138 knots, as the target approach speed.

Glideslope track managed mode became disengaged (G/S disappeared on FMA) when another vertical mode engaged, and this case, altitude hold mode became engaged (ALT appeared on the FMA).

Localizer capture managed mode became disengaged (LOC* disappeared on FMA) since another lateral mode engaged, and this case, navigation managed mode became engaged (NAV appeared on the FMA).

AP2 on PRIM 1, 2, and 3 became disengaged, while AP1 still engaged. Hence, AP1+2 disappeared, and AP1 appeared on FMA.

The vertical speed selected mode transiently engaged only for about one second without any action performed on the AFS CP (FCU).

The LOC deviation was 1/3 dot (recorded data was +25 µA) with the Aircraft was on the left side of the localizer axis.

At 1816:39, the indicated active waypoints were UUDD on the FMS.

At 1816:49, the Commander radioed Tower control and informed that the flight crew needed to perform go-around again. Radar Controller replied the Commander and instructed to continue approach for runway 14R.

At 1816:51, the Aircraft was levelling at 2,600 feet on heading 140 degrees. The airspeed was 138 knots.

Between 1816:58 and 1817:04, HDG knob was rotated 140 to 148 degrees.

At 1816:59, the Commander again informed Tower control that the flight crew was performing the go-around, and requested Tower Controller to provide them with the heading after the go-around. Radar Controller questioned the flight crew whether go-around was being performed, which then an affirmation was replied by the Commander.

At 1817:13, HDG knob was rotated 148 to 150 degrees. The Aircraft was levelling at 2,596 feet on a heading of 138 degrees. The airspeed was 139 knots, with a target speed of 138 knot.

At 1817:14, HDG knob was pulled which engaged heading selected mode (HDG appeared on FMA), hence, navigation managed mode became disengaged (NAV disappeared on FMA). The Aircraft was maintaining level at 2,596 feet pressure altitude (approximately 600 meters height).

At the same time, Tower Controller instructed the flight crew to follow the published procedure for the go-around by climbing to a height of 600 meters. The Commander queried Tower Controller to repeat the instruction, which then Tower Controller again instructed the flight crew to follow the published procedure for the go-around. The Commander replied that the Aircraft was already maintaining 600 meters on runway track.

Between 1817:15 and 1817:19, HDG knob was rotated from 150 to 155 degrees. Hence, the Aircraft started to turn.

At 1817:19, the navigation managed mode became engaged (NAV appeared on FMA). The heading selected mode became disengaged (HDG disappeared on FMA) since another lateral mode engaged, and in this case, the navigation managed mode became engaged.

At 1817:38, HDG knob was rotated from 155 to 159 degrees.

1817:41, HDG knob was pulled which engaged heading selected mode (HDG appeared on FMA), hence, navigation managed mode became disengaged (NAV disappeared on FMA). The Aircraft was maintaining level at 2,604 feet pressure altitude (approximately 600 meters radio height).

Between 1817:44 and 1817:48, HDG knob was rotated from 159 to 150 degrees.

At 1817:53, the navigation managed mode became engaged (NAV appeared on FMA). The heading selected mode became disengaged (HDG disappeared on FMA) since another lateral mode engaged, and in this case, the navigation managed mode became engaged.

At 1817:54, Tower Controller instructed the flight crew to turn left onto a heading of 070 degrees, and to contact Domodedovo Radar control on 127.7 MHz. The Commander only read back Tower Controller about the turning onto a heading of 070 degrees.

Between 1818:03 and 1818:09, HDG knob was rotated to 70 degrees.

At 1818:15, the Commander informed Tower Controller that the Aircraft was turning left to heading 070 degrees and maintaining level at 600 meters height. Tower Controller

affirmed the turning to heading 070 degrees and instructed to contact Radar control on 127.7 MHz, which then read back correctly by the Commander.

At 1818:29, HDG knob was pulled which engaged heading selected mode (HDG appeared on FMA), hence, navigation managed mode became disengaged (NAV disappeared on FMA). The Aircraft was maintaining level at 2,600 feet pressure altitude.

At 1818:40, according to FMS BITE, new destination UUDD was inserted as a new destination for the active flight plan. The new destination revision (NEW DEST) was used to define UUDD as the new destination for the active flight plan (menu on the ACTIVE / F-PLN page of the FMS on the MFD). Insertion of UUDD as the new destination, deleted all waypoints on the flight plan between the revised waypoint and the new destination, and inserted a flight plan discontinuity in their place.

At 1818:43, the flaps lever position was moved from configuration 'FULL' to '3'. Hence, slats/flaps started to move from 23º/33º, and reached 23º/26º at 1818:51.

At 1818:47, landing gear lever was set to UP position. Hence, all gears started to retract, and reached full up and locked position at 1819:05.

At 1819:07, the Aircraft reached heading 070 degrees and maintained that magnetic heading. According to FMS BITE, the Approach ILS 14R was inserted (temporary insertion) on the ARRIVAL page. It means that Approach ILS 14R was available on the temporary flight plan, which was considered as a single lateral flight plan revision.

At 1819:10, SPD Knob was pulled which engaged speed selected mode, and disengaged speed managed mode.

Between 1819:11 and 1819:14, SPD knob was rotated from 146 to 154 knots. The airspeed was 146 knots and continued increasing.

Between 1819:23 and 1819:27, SPD knob was rotated from 154 to 170 knots. The airspeed was 150 knots and continued increasing.

At 1819:32, Tower Controller again instructed the flight crew to contact Radar control on 127.7MHz. This Radar instruction came about one minute after the last Commander read back to Radar Controller of the acknowledgment to contact Tower.

At 1819:37, the flaps lever position was moved from configuration '3' to '1'. Hence, slats/flaps started to move from 23º/26º. The slats reached 20º at 1819:44, and the flaps reached 8º at 1819:49.

Between 1819:39 and 1819:40, SPD knob was rotated from 170 to 183 knots. The airspeed was 165 knots and continued increasing. The Aircraft was maintaining 2,616 feet pressure altitude (bit higher than 600 meters radio altitude).

At 1819:40, Radar Controller contacted the flight crew and the Commander then informed Radar Controller that the Aircraft was maintaining 600 meters height on a heading of 070 degrees.

At 1819:43, according to FMS bite, II14R waypoint was inserted using DIR TO CRS IN function. The navigation managed mode became armed (NAV appeared on FMA).

A lateral revision of the flight plan was performed by inserting a waypoint using the DIR TO CRS IN function. The intention was to revise the flight plan by selecting II14R (IF) as the new waypoint to take the Aircraft to the beginning of the ILS 14R straight-in approach segment. The DIR TO CRS IN function created a direct leg from the Aircraft present position to intercept an inbound course of II14R (IF) waypoint.

The Aircraft was at about three nautical miles from the extended runway centreline.

Multi-waypoint sequencing thereafter were logged in the FMS BITE (II14R, DD142, UUDD14R, 990 and INTCPT) until 1820:03. There was no single auto-reset of the FMS. The active waypoint became R185I (missed approach turning point to join the hold pattern anchored to AO waypoint).

At 1819:48, Radar Controller instructed the flight crew to climb the Aircraft to 900 meters height (3,550 feet QNH) and to maintain that height, on the present heading of 070 degrees. Radar Controller also provided no speed limit to the Aircraft. The Commander read back Radar Controller correctly.

At 1820:00, navigation managed mode became engaged (NAV appeared on FMA), which automatically disarmed the mode (NAV disappeared on FMA). The heading selected mode became disengaged (HDG disappeared on FMA) since another lateral mode engaged, and in this case, the navigation managed mode.

At 1820:02, Radar Controller instructed the flight crew to climb the Aircraft to 800 meters height (3,220 feet QNH) and to maintain that height, which the Commander then read back correctly.

At 1820:03, HDG knob was pulled which engaged heading selected mode (HDG appeared on FMA), hence, navigation managed mode became disengaged (NAV disappeared on FMA). The Aircraft was maintaining level at 2,608 feet pressure altitude.

The indicated active waypoints were R185I on the FMS flight plan.

Between 1820:10 and 1820:11, ALT knob was rotated from 2,600 to 3,300 feet.

At 1820:12, ALT Knob was pulled which engaged open climb selected mode (OP CLB appeared on FMA). Hence, altitude hold mode became disengaged (ALT disappeared on FMA) since other vertical mode (open climb selected mode) engaged.

The autothrust speed mode disengaged (SPEED disappeared on FMA), and autothrust climb mode engaged (THR CLB appeared on FMA) since the open climb selected mode engaged.

The altitude hold mode became armed (ALT appeared on the FMA) since open climb selected mode engaged.

At 1820:15, Radar Controller queried the flight crew about the reason of the go-around. The Commander replied and answered that the Aircraft was not stable again for the approach. He also queried Radar control to provide new radar vectors for the next attempt of approach.

Between 1820:16 and 1820:18, SPD knob was rotated from 183 to 200 knots. Hence, the airspeed thereafter started to increase. At the end of the knob rotation, the Aircraft started to climb.

Third Approach of ILS 14R and Landing

At 1820:29, Radar Controller queried an affirmation from the flight crew regarding the requested radar vectors for the next approach, which the Commander then affirmed.

At 1820:34, Radar Controller instructed the flight crew to turn left the Aircraft onto a heading of 340 degrees. The Commander read back Radar Controller correctly.

At 1820:35, the Aircraft was climbing passing 2,956 feet. The altitude capture mode became engaged (ALT* displayed on the FMA) and the altitude hold mode became disarmed (ALT disappeared on the FMA), since the Aircraft reached the capture zone of the (AFS CP) selected altitude target of 3,300 feet. The open climb selected mode became disengaged (OP CLB disappeared on FMA) since another vertical mode (altitude capture mode) engaged.

The autothrust speed mode engaged (SPEED appeared on FMA), and autothrust climb mode disengaged (THR CLB disappeared on FMA) since open climb selected mode disengaged.

At 1820:36, the flaps lever position was moved from configuration '1' to '0'. Hence, slats/flaps started to move from 20º/8º. The flaps reached 0º at 1821:03, and the slats reached 0º at 1821:16.

At 1820:41, the airspeed reached 200 knots, and maintained.

Between 1820:44 and 1820:49, HDG knob was rotated from 070 to 340 degrees. Thereafter, the Aircraft started to turn left. The Aircraft was climbing through 3,180 feet pressure altitude, when knob was started rotated.

At 1820:48, Radar Controller provided information to the flight crew of the QFE 994 and QNH 1015 settings. Radar Controller instructed again the flight crew to turn the Aircraft onto a heading of 340 degrees, and to maintain at 800 meters height. No speed limitation was also provided. The Commander then read back Radar Controller correctly.

At 1820:57, altitude hold mode became engaged (ALT displayed on the FMA) and altitude capture mode became disengaged (ALT* disappeared on the FMA) since the Aircraft reached the altitude target. The Aircraft was climbing through 3,268 feet pressure altitude (2,890 feet radio height).

Between 1821:00 and 1821:02, SPD knob was rotated from 200 to 210 knots. Accordingly, the airspeed started to increase.

At 1821:07, the Aircraft reached 3,320 feet pressure altitude and maintained that level.

At 1821:17, Radar Controller instructed the flight crew to turn the Aircraft onto a heading of 310 degrees, which the Commander then read back correctly.

At 1821:21, AO waypoint was inserted using DIR TO function, which created a direct leg between the Aircraft present position and AO waypoint. The flight plan waypoints between Aircraft's present position and AO waypoint were deleted.

The navigation managed mode became engaged (NAV appeared on FMA) since the flight crew inserted AO waypoint using DIR TO function on the MFD. The heading selected mode became disengaged (HDG disappeared on FMA) since another lateral mode engaged, in this case, the navigation managed mode.

Between 1821:21 and 1821:24, HDG knob was rotated from 340 to 310 degrees.

At 1821:24, the indicated active waypoints were AO on the FMS flight plan.

At 1821:26, the airspeed reached 210 knots and maintained. The Aircraft was turning left passing a heading of 350 degrees.

1821:40, HDG knob was pulled which engaged heading selected mode (HDG appeared on FMA), hence, navigation managed mode became disengaged (NAV disappeared on FMA) since another lateral mode (heading selected mode) engaged. The Aircraft was maintaining level at 3,292 feet pressure altitude.

Between 1821:43 and 1821:45, HDG knob was rotated from 310 to 309 and back to 310 degrees.

At 1821:45, according to FMS BITE, new destination from AO was inserted (temporary insertion).

The new destination revision (NEW DEST) was used to define AO waypoint as the new destination for the temporary flight plan (menu on the F-PLN page of the FMS on the

MFD). Insertion of AO waypoint as the new destination, deleted all waypoints on the flight plan between the revised waypoint and the new destination, and inserted a flight plan discontinuity in their place.

At 1822:08, according to FMS BITE, the Approach ILS 14R was inserted into the active flight plan on the ARRIVAL page, which means that Approach ILS 14R was available on the active flight plan.

At 1822:11, Radar Controller instructed the flight crew to turn left the Aircraft onto a heading of 290 degrees, which the Commander read back correctly.

Between 1822:15 and 1822:17, HDG knob was rotated from 310 to 290 degrees. The Aircraft was turning left through 327 degrees at the start of the knob rotation.

At 1822:24, Radar Controller instructed again the flight crew to turn the Aircraft to heading 290 degrees, which the Commander read back correctly.

At the same time, according to FMS BITE data, II14R waypoint was inserted using DIR TO function, which created a direct leg between the Aircraft present position and II14R waypoint.

At 1822:27, HDG knob was pulled (it was actually not required). The navigation managed mode (NAV mode) became armed for about one second, and became disarmed again, since heading selected mode was already in an engagement condition before the HDG was pulled. The heading mode remained engaged thereafter.

At 1822:31, the indicated active waypoints were II14R on the FMS flight plan.

At 1822:41, the Aircraft reached heading 290 degrees, and maintained thereafter that heading. The Aircraft was maintaining level at 3,300 feet pressure altitude with a constant airspeed of 210 knots.

At 1823:32, Radar Controller queried the flight crew to explain more details of the issue on the decision of the second go-around. The Commander then replied that the issue was an unstable approach. He also queried Radar Controller to provide them another vectoring for the next approach.

At 1823:44, the Aircraft was maintaining level at 3,296 feet pressure altitude (a bit higher than 800 meters height) on a heading of 290 degrees. The airspeed maintained at about 210 knots.

At the same time, Radar Controller instructed the flight crew to turn left the Aircraft onto a heading of 230 degrees and to maintain 800 meters height. No speed limit was also given. The Commander read back Radar Controller correctly.

Between 1823:50 and 1823:56, HDG knob was rotated from 290 to 230 degrees. Thereafter, the Aircraft started to turn left.

Between 1823:58 and 1823:59, SPD Knob was rotated from 210 to 200 knots. Hence, the airspeed started to decrease thereafter.

At 1824:29, the airspeed reached 200 knots and maintained.

At 1824:30, flaps lever position was set to configuration ‘1’. Hence, slats/flaps started to move from 0º/0º. The flaps reached 8º at 1824:56, while the slats reached 20º at 1825:07.

At 1824:33, Radar Controller provided the flight crew a clearance for ILS approach runway 14R, on heading 230 degrees to establish the localizer, at 800 meters height. The commander read back correctly, and queried to Radar Controller for speed discretion which then approved by Radar Controller.

At 1824:36, the Aircraft reached heading 230 degrees and maintained that heading.

At 1824:39, APPR push button was pressed which enabled the Aircraft to fly ILS runway 14R approach. The glideslope mode (G/S) and localizer mode (LOC) became armed as displayed on FMA.

The localizer mode and glideslope mode became armed, which means that at least one ILS receiver was operative. In addition, at least one radio altimeter was operative. From the two available radio altitude parameters of the FDR, both radio altimeters were operative.

At 1824:41, AP2 push button was pressed, hence AP2 on PRIM 1, 2 and 3 became engaged (AP1+2 appeared and AP1 disappeared on FMA), which means that both autopilot AP1 and AP2 were engaged, since AP1 was already engaged. AP1 was the active one, and AP2 was on standby.

At 1824:50, SPD knob was pushed which engaged speed managed mode.

The airspeed started to decrease from 200 knots by following the target speed, which was 177 knots. While the target approach speed was138 knots.

At 1824:54, SPD knob was pulled which engaged the speed selected mode, and disengaged the speed managed mode.

Between 1824:54 and 1824:56, SPD knob was rotated from 198 to 178 knots. Accordingly, the target speed on the FCU/AFS CP and the target speed controlled by the flight guidance/autoflight system (FM/FGC) became 178 knot. The target approach speed remained at 138 knots

At 1824:59, flaps lever position was set to configuration '2'. Hence, flaps started to move from 8º and reached 17º at 1825:07. The slats stayed at 20º.

At 1825:03, SPD knob was pushed which engaged the speed managed mode became engaged, and disengaged the speed selected mode. The airspeed was decreasing through 189 knots.

At 1825:07, landing gear lever was set to DOWN position. Hence, all gears started to extend and reached full down position at 1825:22.

At 1825:20, Radar Controller questioned whether the flight crew were ready to continue ILS approach for runway 14R. The Commander replied and informed Radar Controller that they were ready, and acknowledged by Radar Controller.

At 1825:22, the target approach speed became139 knots.

At 1825:31, the Aircraft's airspeed was decaying through167 knots. The flaps lever position was set to configuration '3'. Hence, slats/flaps started to move from 20º/17º. Five seconds later, at 1825:36, the flaps lever position was set to configuration 'FULL'. The slats reached 23º at 1825:38, while the flaps reached 33º at 1825:43.

At 1825:42, SPD knob was pushed (it was actually not necessary to push it since the speed managed mode was already engaged).

At 1826:04, the airspeed reached the target approach speed of 139 knots, and maintained.

At 1826:08, ALT knob was rotated from 3,300 to 3,200 feet.

At 1826:10, V/S knob was pulled which engaged the vertical speed selected mode (V/S +0 appeared on FMA), hence, the altitude hold mode became disengaged (ALT disappeared on the FMA).

Between 1826:10 and 1826:11, V/S knob was rotated from 0 to -320 fpm (V/S -320 appeared on FMA). The altitude hold mode became armed (ALT appeared on the FMA) since

the Aircraft was targeted to the next altitude, 3,200 feet pressure altitude, as selected on the AFS CP.

At 1826:19, the target speed controlled by the flight guidance/autoflight system (FM/FGC) became 138 knots, and as the target approach speed.

At 1826:21, the Aircraft started to descend with a vertical speed of -320 fpm, as selected. The airspeed maintained at 138 knots, and the heading on 230 degrees.

Between 1826:28 and 1826:30, HDG knob was rotated from 230 to 185 degrees.

At 1826:29, the altitude capture mode became engaged (ALT* appeared on the FMA) and the altitude hold mode became disarmed (ALT disappeared on the FMA) since the Aircraft reached the capture zone of the altitude target of 3,200 feet. The Aircraft was descending passing 3,236 feet pressure altitude. Consequently, the vertical speed selected mode became disengaged (V/S-320 disappeared on FMA). Thereafter, the Aircraft started to turn left.

At 1826:31, altitude hold mode became engaged (ALT displayed on the FMA) and altitude capture mode became disengaged (ALT* disappeared on the FMA) since the Aircraft reached the selected altitude of 3,200 feet. The Aircraft was descending through 3,228 feet pressure altitude (2,744 feet radio height).

At 1826:32, Radar Controller informed that the Aircraft was approaching final, and instructed the flight crew to turn left the Aircraft to establish the localizer and to report when established.

Between 1826:32 and 1826:34, HDG knob was rotated from 185 to 178 degrees.

Between 1826:39 and 1826:41, HDG knob was rotated from 178 to 165 degrees.

At 1826:40, Radar Controller again instructed the flight crew to turn left the Aircraft in order to establish the localizer and to report when established. The Commander replied Radar Controller by mentioning ‘UAE 131’.

The Aircraft was maintaining level at approximately 3,200 feet pressure altitude.

At 1826:43, the indicated active waypoints were DD142 on the FMS flight plan.

At 1826:48, HDG knob was rotated from 165 to 181 degrees. The Aircraft was turning left through heading 190 degrees.

Between 1826:56 and 1826:58, HDG knob was rotated from 181 to 175 degrees. The Aircraft was turning left through heading 175 degrees with an airspeed of 139 knots.

At 1827:02, HDG knob was rotated from 175 to 176 degrees.

At 1827:09, localizer capture managed mode engaged (LOC* appeared on FMA) and localizer track mode disengaged (LOC disappeared on FMA) since the Aircraft reached the capture zone, or the pre-capture zone of the LOC beam. The heading selected mode became disengaged (HDG disappeared on FMA) since another lateral mode (localizer capture managed mode) engaged. The Aircraft was maintaining level at 3,204 feet pressure altitude on a heading of 176 degrees, and the airspeed was 138 knots.

The localizer deviation was 4.1 dot (recorded data was +305 µA) with the Aircraft was on the left side of the localizer axis).

At 1827:13, Radar Controller queried the flight crew for confirmation whether the Aircraft already established the localizer. The Commander replied and mentioned that the Aircraft fully established on the localizer of the ILS approach runway 14R.

At 1827:14, glide slope capture mode engaged (G/S* appeared on FMA) and glide slope track mode became disarmed (G/S disappeared on FMA) since the Aircraft reached the

capture zone of the glideslope (G/S) beam. The altitude hold mode became disengaged (ALT disappeared on the FMA) since another vertical mode (glide slope capture mode) engaged.

At 1827:20, Radar Controller questioned the flight crew whether the Aircraft was ready to continue the approach. The Commander replied and mentioned that they are ready to continue the approach.

At 1827:24, Radar Controller instructed the flight crew to contact Domodedovo Tower control on 118.6 MHz, which then read back correctly by the Commander.

At 1827:27, the indicated active waypoints were UUDD14R on the FMS flight plan.

At 1827:29, glide slope track mode engaged (G/S appeared on FMA) and glide slope capture mode became disengaged (G/S* disappeared on FMA) since the Aircraft became established on the glideslope beam. The Aircraft was descending through 3,068 feet pressure altitude, and turning left through heading 155 degrees. The airspeed was 142 knots.

At 1827:53, Localizer track mode engaged (LOC appeared on FMA) and localizer capture mode engaged (LOC* disappeared on FMA) since the Aircraft became established on the localizer (LOC) beam. The Aircraft was descending through 2,744 feet pressure altitude (2,318 feet radio height) on heading 142 degrees. The airspeed was 138 knots.

At 1828:08, Tower radioed the Aircraft, which the Commander then replied and mentioned that the Aircraft already established on ILS runway 14R.

At 1828:12, Tower Controller instructed the flight crew to continue the approach. The Commander read back Tower Controller correctly.

At 1829:23, Tower Controller provided the flight crew wind surface information for runway 14R: wind direction of 180 degrees and speed of 3 meters per second. Tower Controller also provided landing clearance to the flight crew. The Commander replied Tower Controller and asked for confirmation of the landing clearance.

At 1829:33, Tower Controller confirmed the landing clearance. The Commander read back Tower Controller correctly.

At 1830:14, both autopilots on PRIM 1, 2, and 3 became disengaged which indicated by the disappearing of AP1+2 on the FMA. The aircraft was descending through 1,112 feet pressure altitude (521 feet radio altitude) on a heading of 143 degrees, and the airspeed was 139 knots.

At 1830:27, glide slope track mode and localizer track mode became disengaged (G/S and LOC disappeared on FMA) since the land mode engaged (LAND appeared on the FMA). This means that the Aircraft was below 400 feet radio height, and actually, the Aircraft was descending through 968 feet pressure altitude (362 feet radio altitude) on a heading of 142 degrees, and the airspeed was 138 knots.

At 1830:54, flare mode engaged as indicated by appearing of FLARE on the FMA, and land mode became disengaged as indicated by disappearing of LAND on the FMA since the Aircraft reached 60 feet. The Aircraft was descending through 636 feet pressure altitude (53 feet radio altitude) on a heading of 137 degrees, and the airspeed was 139 knots.

At 1830:57, autothrust on PRIM 1, 2, and 3 was disengaged. At this time, the Aircraft was descending through 580 feet pressure altitude (21 feet radio altitude) on a heading of 137 degrees, and the airspeed was 138 knots. Consequently, the autothrust speed mode disengaged (SPEED disappeared on the FMA).

1831:01, the indicated active waypoints were 990 on the FMS flight plan.

At 1831:03, roll out mode engaged (ROLL OUT appeared on FMA) and flare mode became disengaged (FLARE disappeared from the FMA) since the Aircraft touched down.

At 1831:59, the Tower Controller instructed the flight crew to turn left to taxiway H2. The Commander read back the instruction of the left turning, and queried to repeat the taxi instruction. Tower Controller instructed the flight crew to report before reaching taxiway H2. The Commander queried whether he could maintain the present radio frequency. However, Tower Controller instructed the flight crew to contact Domodedovo Apron on 119.0 MHz, which then correctly replied by the Commander.

At 1840:14, all engines were shutdown.

Appendix 2. LIDO Charts

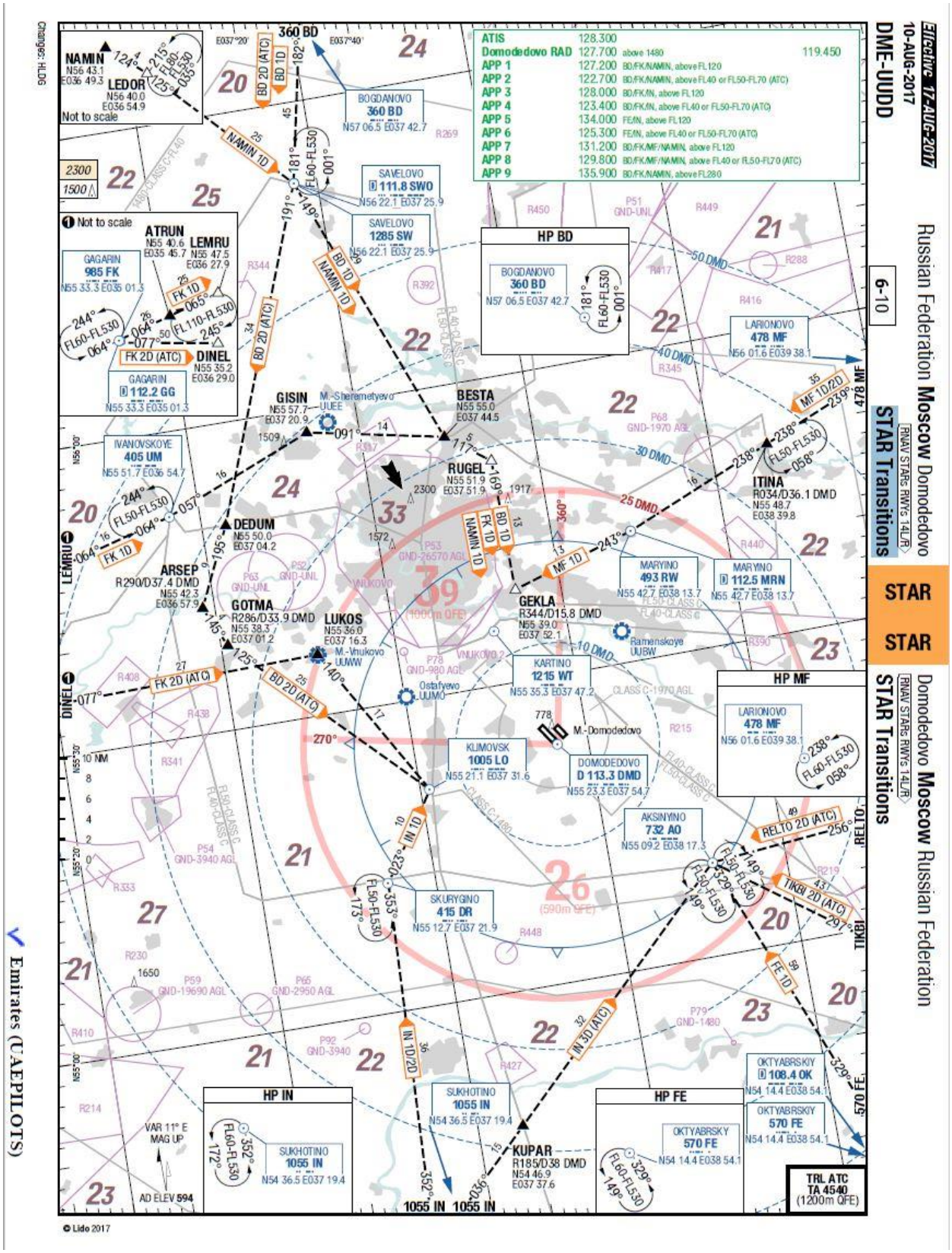

Figure A2.1 – UUDD runway 14L/R STAR transitions chart

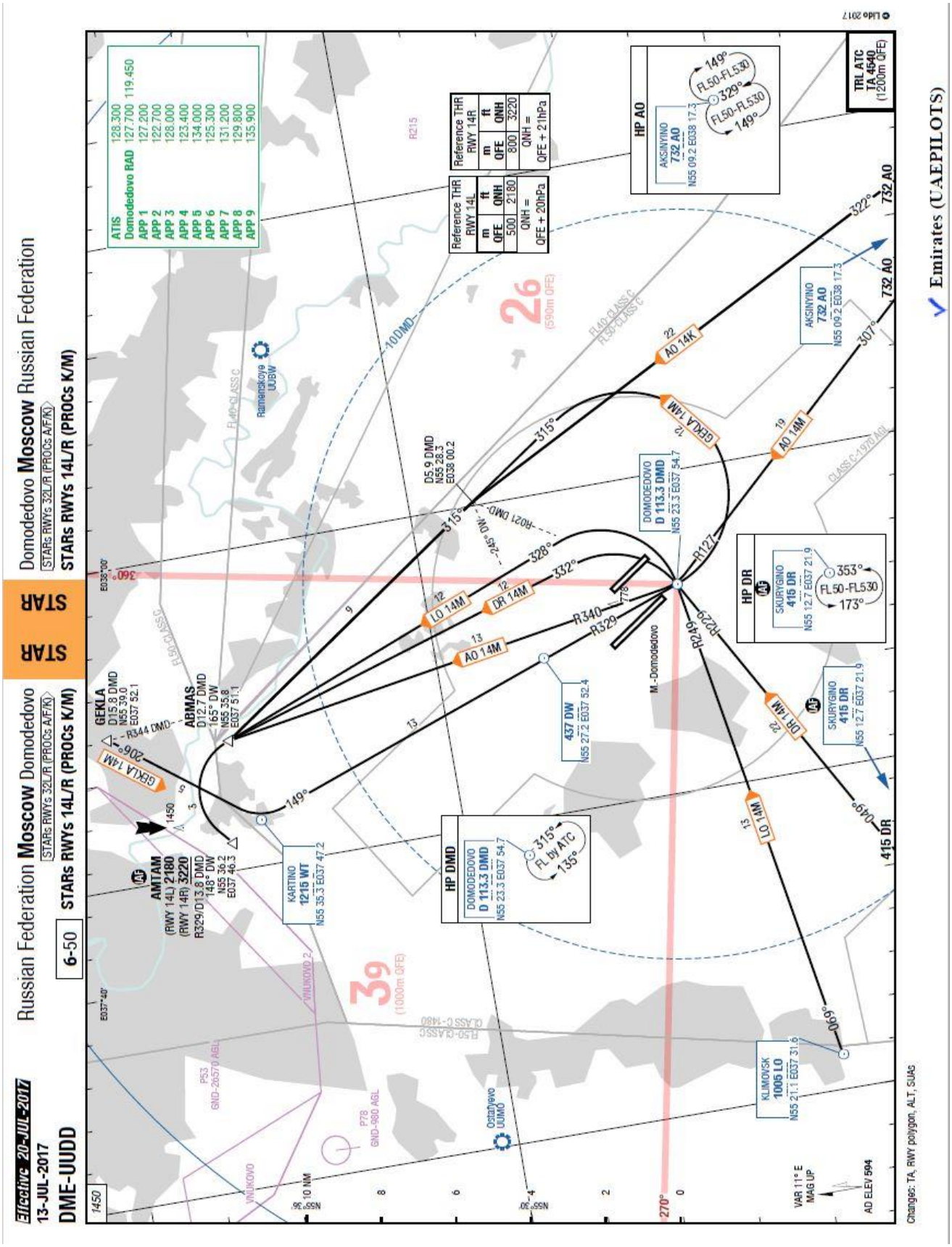

Figure A2.2 – UUDD STAR runway 14L/R chart

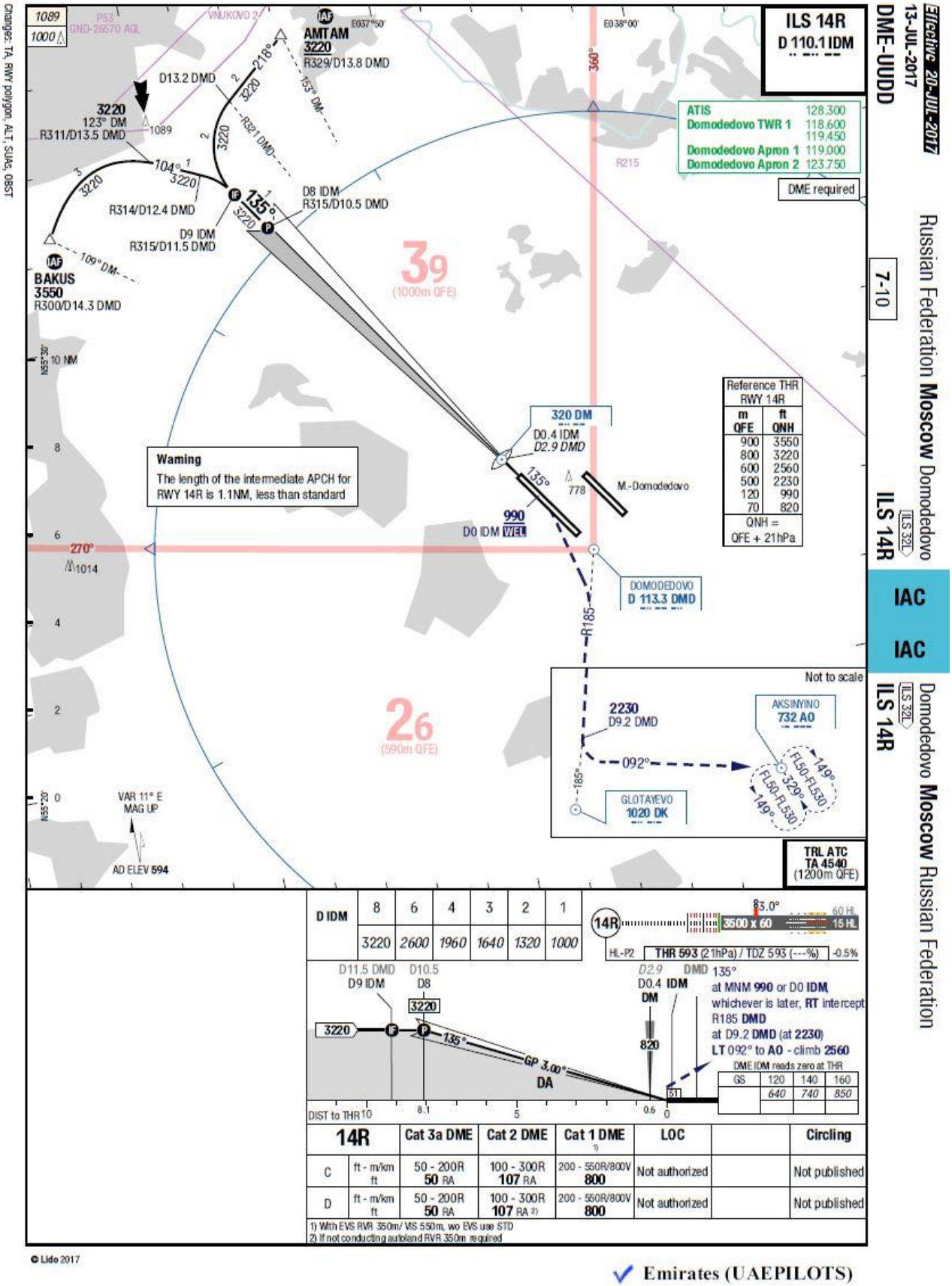

Figure A2.3 – UUDD ILS runway 14R chart

Appendix 3. Standard Operating Procedures (SOP)

App-3.1 SOP for Approach according to the *FCOM* – Aircraft configuration management

The standard operating procedures (SOP) for the aircraft configuration management for an ILS approach according to the *Flight Crew Operating Manual* covers the approach phases: initial approach, and intermediate/final approach.

Initial approach

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INITIAL APPROACH

For more information, *Refer to FCTM/PR-NP-SOP-190-CONF Initial Approach.*

F-PLN SEQUENCING ..... ADJUST | PF

The NAV mode will be available after GO AROUND if the F-PLN is correctly sequenced. A good way to monitor the correct F-PLN sequencing is the TO waypoint on the upper right side of the ND, which should remain appropriate.
In NAV mode, the F-PLN waypoints automatically sequence.
In HDG/TRK mode, the F-PLN waypoints automatically sequence only if the aircraft flies close to the F-PLN route.

APPROACH PHASE ..... CHECK/ACTIVATE | PF-PM

- *If the aircraft overflies the DECEL pseudo waypoint in NAV mode, the APPR phase activates automatically*
- *If the aircraft is in HDG or TRACK mode approximately 15 NM from touchdown, activate and confirm the APPR phase on the FMS ACTIVE/PERF page.*

MANAGED SPEED ..... CHECK | PF

If ATC requires a particular speed, use selected speed. When the ATC speed constraint no longer applies, return to managed speed.

FLIGHT PATH ..... MONITOR | PF

- *In NAV mode, use the VERT DEV on the PFD and on the DES panel of the ACTIVE/PERF page*
- *In HDG or TRACK mode, use the energy circle on the ND that shows the required distance to land.*

SPEED BRAKES ..... AS RQRD | PF

If the flight crew uses the speed brakes to increase the rate of deceleration or to increase the rate of descent, VLS increases.

As a result:

- *The flight crew should check that the speed margin is appropriate before the extension of the speed brakes*
- *If the speed brakes are extended, the flight crew should check that the speed margin is appropriate before the beginning of a turn.*
  Below VFE NEXT, the flight crew should consider FLAPS 1, particularly if the flight crew intends to perform a turn above 20 ° of bank angle. This FLAPS 1 selection increases the speed margin to VLS, which provides additional roll manoeuvrability.

This will avoid the activation of the α-floor protection.

"

Intermediate/final approach

"

APPROACHING GREEN DOT SPEED

For additional information on the associated standard callouts:

- *Refer to PRO-NOR-SCO Flaps or Gear Configuration*
- *Refer to PRO-NOR-SCO Flight Parameters In Approach.*

FLAPS 1 ..... ORDER | PF
FLAPS 1 ..... SELECT | PM

- *The flight crew should not set FLAPS 1 later than 3 NM from the final descent point*
- *Check the aircraft deceleration toward S speed*
- *The aircraft must reach, or be established on, the final descent point with FLAPS 1 and S speed at or above 2 500 ft AGL*
- *On the final descent path, if the aircraft speed is significantly above S, or if the aircraft does not decelerate, extend the landing gear in order to decelerate the aircraft.*
  The flight crew can also use the speed brakes. However, the flight crew should be aware of the VLS increase, and the limited effect of the speed brakes at low speeds.

TA pb ..... TA ONLY or TA/RA | PM

The flight crew may use the TA ONLY mode in specific airports, and for specific procedures (identified by Operators) that may provide resolution advisories that are neither wanted nor appropriate (e.g. closely-spaced parallel or converging runways).

AT 2500 FT AGL MINIMUM

For additional information on the associated standard callouts, *Refer to PRO-NOR-SCO Flaps or Gear Configuration.*

FLAPS 2 ..... ORDER | PF
FLAPS 2 ..... SELECT | PM

- *Check the aircraft deceleration toward F speed*
- *For ILS and GLS approaches and approaches using FLS, if the aircraft intercepts the flight path below 2 500 ft AGL, select FLAPS 2 at one dot below the flight path*
- *If the aircraft speed is significantly above F on the flight path, or if the aircraft does not decelerate on the flight path, extend the landing gear in order to decelerate the aircraft. The use of the speed brakes is not recommended.*

AFTER FLAPS 2 SELECTION, AT 2000 FT AGL MINIMUM

For additional information on the associated standard callouts, *Refer to PRO-NOR-SCO Flaps or Gear Configuration*.

L/G DOWN	ORDER	PF
L/G	DOWN	PM
AUTO BRK	CONFIRM	PM

During the approach, if the runway conditions deteriorated since the approach briefing but they remain compatible with the backup in-flight landing performance assessment associated with the worst likely conditions considered during the briefing, the flight crew can increase the level of the autobrake mode.
When BTV is selected, if the aircraft lands on a runway different from the runway selected for BTV settings, the autobrake reverts automatically to autobrake mode HI in short final. Pedal override (or A/THR instinctive disconnect pb if not ROP is active) remains possible on ground to moderate the braking, when safe.

GND SPLRS	ARM	PM
EXTERIOR LIGHTS	SET	PM

Set:
- *The NOSE sw to T.O*
- *The RWY TURN OFF & CAMERA sw to ON*
- *The LAND sw to ON.*

AFTER LANDING GEAR DOWN SELECTION

For more information on the associated standard callouts, *Refer to PRO-NOR-SCO Flaps or Gear Configuration*.

FLAPS 3	ORDER	PF
FLAPS 3	SELECT	PM
WHEEL SD PAGE	CHECK	PM

- *The WHEEL SD page appears below 800 ft, or at landing gear extension*
- *Check the five landing gear green indications. At least one green triangle on each landing gear strut is sufficient to indicate that this landing gear strut is down and locked.*

For more information on the associated standard callouts, *Refer to PRO-NOR-SCO Flaps or Gear Configuration*.

FLAPS FULL	ORDER	PF
FLAPS FULL	SELECT	PM

Check that the aircraft decelerates to VAPP.

A/THR	CHECK IN SPEED MODE or OFF	PM
SLIDING TABLE	STOWED	BOTH
LDG MEMO	CHECK NO BLUE	PM
CABIN CREW	ADVISE	PM

Advise the cabin crew that landing is imminent.

CABIN	READY	BOTH

Check CABIN READY on the EWD, or obtain the report from the chief purser: "Cabin ready for landing".

LANDING C/L	COMPLETE	BOTH

For more information, Refer to PRO-NOR-C-L Landing.

For more information on the associated standard callouts, Refer to PRO-NOR-SCO Summary for Each Flight Phase.

FLIGHT PARAMETERS	MONITOR	PM

The PF announces any modification on the FMA.

The PM announces any flight parameter deviation. For more information on the associated callouts, Refer to PRO-NOR-SCO Flight Parameters In Approach.

If the PM announces a flight parameter deviation, the appropriate PF response must:

- *Acknowledge the PM callout, for appropriate flight crew coordination*
- *Take immediate corrective action to bring the parameter back into the defined stabilized conditions*
- *Assess whether stabilized conditions will be recovered early enough prior to landing. If not, initiate a go-around.*

"

App-3.2 SOP for Approach according to the *FCOM* – Aircraft guidance management

The standard operating procedures (SOP) of the aircraft guidance management for ILS approach, means using localizer (LOC) and glideslope (G/S) guidance according to the *Flight Crew Operating Manual* covers the approach phases: initial/intermediate approach, glideslope intercept from above, final approach, at minimum+100 feet, and at minimum.

Initial/Intermediate approach

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INITIAL/INTERMEDIATE APPROACH

For additional information on the FMA display during this phase of flight, *Refer to DSC-22-FG-70-120-90 ILS Approach and Autoland.*
For more information on the associated standard callouts, *Refer to PRO-NOR-SCO Summary for Each Flight Phase.*

APPR pb on AFS CP..... PRESS | PF

- *Press the APPR pb when:*
  - *Cleared for the approach*
  - *On the intercept trajectory for the final approach course*
  - *LOC deviation is available.*

  Note: In NAV mode, the aircraft may leave the F-PLN to capture the LOC.

- *LOC and/or G/S modes engage not sooner than 3 s after being armed*
- *The ICAO defines the envelope in which the quality of the glideslope (G/S) signal ensures a normal capture. This envelope is within 10 NM, ± 8 ° from the centerline of the ILS glide path, and up to 1.75 teta (teta, being the nominal glide path angle). If the approach is armed when the aircraft is far outside from the standard G/S capture envelope, a spurious G/S* engagement may occur, due to an incorrect G/S deviation signal. Each time that the flight crew notices pitch movement, or a spurious G/S*, or a trajectory deviation, they must immediately disconnect the AP, if engaged, in order to re-establish a normal attitude and disengage APPR mode. It is then recommended to arm/rearm the APP (ILS) mode within the normal capture zone.*

Note: If the flight crew selects a non-precision approach on the FMS ARRIVAL page in the active flight plan, and if they manually tune an ILS on the FMS POSITION/NAVAIDS page, the MFD and PFD display CHECK APPR SEL. The available approach guidance modes are LOC and G/S modes when the APPR pb is pressed on the AFS CP. Therefore, the approach selected on the FMS ARRIVAL page is disregarded and the aircraft will fly the manually-tuned ILS approach on the FMS POSITION/NAVAIDS page.

AP 1+2..... ON | PF

- *When APPR mode is selected, AP1 and AP2 should be engaged*
- *Above 5 000 ft AGL, the FMA displays CAT 1 capability or the approach capability depending on the RA performance due to external conditions*
- *Below 5 000 ft AGL, the FMA displays the correct approach capability for the intended approach.*

LOC..... CHECK ARMED | PF
G/S..... CHECK ARMED | PF
LOC CAPTURE..... MONITOR | PF
G/S CAPTURE..... MONITOR | PF

Check that the aircraft sequences the waypoints associated to the final descent point, at the altitude specified on the published approach chart.

GO-AROUND ALTITUDE..... SET | PF-PM ,,

Glideslope interception from above

“

GLIDE INTERCEPTION FROM ABOVE

The following procedure should only be applied when established on the localizer. The flight crew must react without delay to meet the stabilization criteria. In order to get the best rate of descent when cleared by ATC and below the limiting speeds, the flight crew should lower the landing gear and select flaps as required (at least CONF 2 should be selected to ensure that the aircraft speed will not increase).

- **If above the glideslope:**

  APPR mode.....ARM/CHECK ARMED | PF
  AFS CP ALTITUDE.....SET ABOVE A/C ALTITUDE | PF

  Select an altitude above the aircraft altitude, in order to prevent inadvertent ALT engagement.*

  V/S MODE.....SELECT | PF

  Do not exceed 2 000 ft/min.

"

Final approach

"

FINAL APPROACH

FLIGHT PARAMETERS.....MONITOR | PM

The PM calls out if excessive deviation occurs:
- *LOC: ½ dot*
- *GLIDE: ½ dot.*

For more information on the associated callouts, Refer to PRO-NOR-SCO Flight Parameters in Approach.

- **At 500 ft AGL (or RA) and below and if the flight crew selected BTV autobrake mode:**

  The PM may take advantage to adjust the ND RANGE selector to display the dry and wet lines on the Airport Navigation display, when the landing is positively considered.

- **At 350 ft AGL (or RA)**

  LAND ON FMA.....CHECK/ANNOUNCE | PF
  ILS (GLS) COURSE.....CHECK | PF

  Check the ILS (GLS) course on the PFD.

CAT III APPROACH WITHOUT DH

In the case of a CAT III approach without DH, the flight crew should enter NONE, NO, NO DH, or NODH in the RADIO entry field of the APPR panel of the ACTIVE/PERF page. This avoids the undue triggering of the HUNDRED ABOVE and MINIMUM auto callouts.
For more information on the associated callouts, *Refer to PRO-NOR-SCO Summary for Each Flight Phase.*
Below 200 ft, the flight crew should perform a go-around if the AUTOLAND light comes on and they have no visual contact.

- **At 200 ft RA, if the flight crew did not detect any failure:**

  CONTINUE.....ANNOUNCE | PF

- **At 100 ft RA:**

  ONE HUNDRED.....MONITOR or ANNOUNCE | PM ,,

At minimum +100 feet

"

AT MINIMUM+100 FT

For additional information on the associated callouts, *Refer to PRO-NOR-SCO Summary for Each Flight Phase.*

ONE HUNDRED ABOVE.....MONITOR or ANNOUNCE | PM „

At minimum

“

AT MINIMUM

For additional information on the associated callouts, *Refer to PRO-NOR-SCO Summary for Each Flight Phase.*

MINIMUM ..... MONITOR or ANNOUNCE | PM

Below minimum, the visual references must be the primary reference until landing.

■ **If visual references are sufficient:**

CONTINUE ..... ANNOUNCE | PF

Do not duck under the glide slope. Maintain a stabilized flight path down to the flare. At 50 ft, one dot below the glide slope means that the aircraft is 7 ft below the glide slope.

■ **If visual references are not sufficient:**

GO-AROUND..... ANNOUNCE | PF

Initiate a go around.

„

App-3.3 SOP for Approach according to the *FCTM* – Aircraft configuration management

The standard operating procedures (SOP) of the aircraft configuration management for general approach according to the *Flight Crew Technique Manual* covers the approach phases: initial approach, intermediate, and final approach.

Initial approach

“

APPROACH PHASE ACTIVATION

Activation of the approach phase initiates a deceleration toward VAPP or toward the speed constraint inserted at the FAF, whichever applies.
When in NAV mode with managed speed/Mach, the approach phase automatically activates when sequencing the deceleration pseudo waypoint D. If an early deceleration is required, the flight crew can activate the approach phase on the APPR panel of the FMS PERF page.
When in HDG mode, e.g. for radar vectoring, the flight crew manually activates the approach phase.
When the approach phase is activated, the magenta triangle (i.e. the target speed) drops to VAPP, whereas the short term managed speed appears as a magenta dot. The short term managed speed is green dot in clean configuration, S in FLAP 1, etc...

As defined in standard operating procedures, there are two approach techniques, there are two approach techniques:
- The decelerated approach
- The early stabilized approach.

If the tailwind at landing reported by ATC or ATIS is more than 10 kt, decelerated approach is not permitted. The approach speed should be stabilized around VLS+5 kt in final approach. ”

Intermediate approach

“

The purpose of the intermediate approach is to bring the aircraft to the FAF at the correct speed, altitude and configuration.

DECELERATION AND CONFIGURATION CHANGE

Managed speed is recommended for the approach. When the approach phase is activated, the A/THR guides the aircraft speed toward the short-term managed speed displayed as a magenta dot. The short-term managed speed is the target speed of the current configuration, whenever higher than VAPP, e.g. green dot for CONF 0, S speed for CONF 1 etc.
The managed speed target displayed either with the numeric value when out of the speed scale or with a magenta triangle when within the speed scale, drops to VAPP.
When the flight crew select FLAPS 1, the Automatic Extension System (AES) automatically limits the slats/flaps extension to CONF 1 as long as the speed exceeds 205 kt. When the speed drops below 205 kt, the slats/flaps extends to CONF 1+F.
To achieve a constant deceleration and to minimize thrust variations, the flight crew should extend the next configuration when reaching the short term target speed+10 kt (IAS must be lower than VFE next). E.g., when the speed reaches green dot+10 kt, the flight crew should select FLAPS 1.
If the flight crew uses selected speed to comply with ATC, they should set the requested speed on the AFS CP. The flight crew can select a speed below the maneuvering speed of the current configuration provided that selected speed is above VLS. When the ATC speed constraint no longer applies, the flight crew should push the SPD/MACH knob on the AFS CP to resume managed speed.
When flying the intermediate approach in selected speed, the flight crew should activate the approach phase. This ensures further correct speed deceleration when resuming managed speed.
If they do not activate the approach phase, the aircraft will accelerate to the previous speed applicable to the descent phase. For this concern, the position of the magenta dot with regard to the selected speed is a valuable cue.

The flight crew can use the speed brakes to increase the deceleration rate, but they should be aware of:
- The increase of VLS with the use of speed brakes
- The limited effect at low speeds.

INTERCEPTION OF FINAL APPROACH COURSE

To ensure a smooth interception of final approach course, the aircraft ground speed should be appropriate, depending on interception angle and distance to the runway threshold. The flight crew refers to the applicable raw data (i.e. LOC, needles), XTK information on ND and wind component for the selection of an appropriate IAS.
Deceleration will not occur automatically as long as lateral mode is HDG.

If ATC provides a new wind for landing, the flight crew updates it on the APPR panel of the FMS ACTIVE/PERF page. ”

Final approach

“

FINAL APPROACH MONITORING

The final approach must be monitored with the available data.
The data to be monitored depends on the guidance modes, as indicated in the following tables.

Guidance Modes	GPS PRIMARY	GPS PRIMARY LOST	
		Navigation accuracy HIGH	Navigation accuracy LOW
LOC G/S	LOC, G/S deviations		

SPEED CONSIDERATION

VAPP

The flight crew defines the approach speed (VAPP) to perform the safest approach. It is a function of gross weight, configuration, headwind, A/THR ON(OFF) and downburst.
In most cases, the FMS provides reliable VAPP on the APPR panel of the ACTIVE/PERF page, when the flight crew inserted the tower wind and FLAPS 3 or FLAPS FULL landing configuration.

The calculated VAPP is equal to VLS + 0.33*(Tower headwind component), with a minimum of VLS + 5 kt and a maximum of VLS + 15 kt (For more information, *Refer to FCOM/DSC-22-27-10-40 VAPP*).

The flight crew can insert:

- A lower VAPP on the APPR panel, down to VLS, if landing is performed with A/THR OFF, with no wind and no downburst, or
- A higher VAPP in the case of suspected strong downburst
- The VAPP calculated by the OIS LDG PERF application if a failure affects the landing performance.

In the case of strong or gusty crosswind greater than 20 kt, VAPP should be at least equal to VLS + 5 kt. The 5 kt increment above VLS may be increased up to 15 kt at the flight crew's discretion.
The flight crew should bear in mind that the wind entered in the APPR panel of the ACTIVE/PERF page considers that the wind direction is in the same reference as the runway direction (e.g. if airport is magnetic referenced, the flight crew inserts a magnetic wind).
The wind direction provided by ATIS and tower is given in the same reference as the runway direction whereas the wind provided by VOLMET, METAR or TAF is always true referenced.
VAPP is computed at predicted landing weight while the aircraft is in CRZ or DES phase. When the APPR phase is activated, VAPP is computed using the current gross weight.
The flight crew should use managed speed for final approach as it provides the Ground Speed Mini protection, even if VAPP was manually inserted.

GROUND SPEED MINI

Purpose

The purpose of the Ground Speed Mini function is to keep the aircraft energy level above a minimum value, whatever the wind variations or gusts.
This enables an efficient management of the thrust in gusts or in longitudinal windshears. The thrust varies in the right direction, but in a smaller range in gusty situations, which explains why the Ground Speed Mini function is recommended in such situations.
Moreover, the Ground Speed Mini function provides additional safety margins in windshears.
Finally, it improves flight crew's awareness of the situation in the case of approaches affected by wind or gust by monitoring the magenta target speed: e.g. a target increase indicates a headwind gust.

Computation

The FG continuously computes an IAS target speed in order to take into account the gusts or wind changes. The FG uses the instantaneous wind component experienced by the aircraft.
Managed speed target = VAPP + 0.33 * (Current Headwind Component - Tower Headwind Component)

The computed IAS target speed is limited by:

- VAPP as the minimum value, in the case of tailwind or if the Current Headwind Component is lower than the Tower Headwind Component
  The Tower Headwind Component has a limit of 10 kt, as a minimum value.
- VFE NEXT, in configuration clean, 1, 2, 3, as the maximum value, in the case of very strong gusts
- VFE - 5 kt, in configuration FULL, as the maximum value, in the case of very strong gusts.

USE OF A/THR

The flight crew should use the A/THR for approaches as it provides accurate speed control.
During final approach, the managed target speed moves along the speed scale as a function of wind variation. The flight crew should ideally check that the target speed is adequate referring to GS on the top left on ND. If the A/THR performance is unsatisfactory, the flight crew should disconnect it and control the thrust manually.
If the flight crew is going to perform the landing using manual thrust, they should disconnect the A/THR before passing 1 000 ft AGL on the final approach.

TRAJECTORY STABILIZATION

The first prerequisite for safe final approach and landing is to stabilize the aircraft as per criteria given in the FCOM *Refer to FCOM/PRO-NOR-SOP-180-Bis-A Stabilization Criteria.*
If, for any reason, one flight parameter deviates from stabilized conditions, the PM announces a callout as stated below:

Flight Parameter Deviation and Associated PM Callout				
Parameter		**Flight Parameter Deviation**		**Callout**
IAS		VAPP +10 kt / -5 kt		"SPEED"
V/S		< -1 000 ft/min		"SINK RATE"
Pitch attitude		+7 °/ -3 °		"PITCH"
Bank angle		5 °		"BANK"
ILS only	Localizer	Excess deviation	1/2 dot PFD	"LOC"
	Glide slope		1/2 dot PFD	"GLIDE"
FLS	F-Localizer	Excess deviation	1/2 dot PFD	"LOC"(1)
	F-Glide slope		1/2 dot PFD	"GLIDE"(1)

Flight Parameter Deviation and Associated PM Callout			
Parameter		**Flight Parameter Deviation**	**Callout**
Approaches with a selected course	Course	1/2 dot on ND (or 2.5 ° (VOR) / 5 ° (ADF (if installed))) XTK greater than 0.1 NM	"COURSE" "CROSS TRACK"
	Altitude at check points	Deviation	"x FT HIGH (LOW)"

(1) *Reaching the minima, if the required visual conditions are met to continue the approach, external visual cues prevail.*

Following a PM callout associated with a flight parameter deviation, the appropriate PF response is:

- Acknowledge the PM callout, for correct crew coordination purposes
- Take immediate corrective action to control the exceeded parameter back into the defined stabilized conditions
- Assess whether stabilized conditions will be recovered early enough prior to landing, otherwise initiate a go-around.

"

App-3.4 SOP for Approach according to the *FCTM* – Aircraft guidance management

The standard operating procedures (SOP) of the aircraft guidance management for general and specific for ILS approach, means using localizer (LOC) and glideslope (G/S) guidance according to the *Flight Crew Technique Manual* covers the approach phases: initial, intermediate, and final approach.

Initial approach

"

USE OF THE VD

Within 25 NM around the navaid in relation to the selected arrival or the approach procedure, the displayed minimum altitude switches from MORA to MSA. MSA displayed on VD is associated with the navaids of the selected procedure.
The flight crew should keep in mind that crossing the safe altitudes during an approach is not always a constraint violation, as long as the flight monitoring is supported by another means, e.g. the radar control. This is why the safe altitude does not appear as a red line (but as a magenta line). However, crossing the safety altitude should alert the flight crew regarding the aircraft position and the ATC clearance, i.e. "I will go below if I am sure of my position and if I am allowed to do it (radar or procedure)".

F-PLN SEQUENCING

In NAV mode, the F-PLN automatically sequences. In HDG (TRACK) mode, the F-PLN waypoints automatically sequence only if the aircraft flies near the programmed route.

A correct F-PLN sequencing is important to ensure that:
- The Vertical Display is meaningful
- The programmed missed approach route is available in the case of go-around
- The predictions are correct.

A good cue to monitor the correct F-PLN sequencing is the TO waypoint on the upper right side of the ND which should be the next waypoint ahead of the aircraft.
If under radar vectors and if automatic waypoint sequencing does not occur, it is recommended to sequence the F-PLN by using the DIR TO COURSE IN function.
Using DIR TO or DIR TO COURSE IN function arms the NAV mode. If the NAV mode is not appropriate, pull the HDG/TRK knob to disarm it.

NAVIGATION ACCURACY

When NAV PRIMARY is available, no NAV ACCURACY monitoring is required.
When NAV PRIMARY is lost the crew will check on MFD POS MONITOR page that the required navigation accuracy is appropriate. If the NAV ACCUR DOWNGRADED message is displayed on the FMS, the crew will use raw data for navigation accuracy check. The navigation accuracy determines which AP modes the flight crew should use and the type of ND display.

NAVIGATION ACCURACY	ND		AP/FD mode
	PF	PM	
NAV PRIMARY	ARC or ROSE NAV with navaid raw data		NAV
NAV ACCUR HIGH			
NAV ACCUR LOW and NAV ACCURACY check ≤1NM			
NAV PRIMARY LOST and NAV ACCUR LOW and NAV ACCURACY check>1NM	ROSE LS	ARC or ROSE NAV or ROSE LS with navaid raw data	HDG or TRK
NAV PRIMARY LOST and aircraft flying within unreliable radio navaid area			

FLYING REFERENCE

It is recommended to select HDG-V/S for ILS approaches. The flight crew flies the FD bars.

APPROACH DEVIATION INDICATIONS

The flight crew checks the LS pb is pressed in the first stage of the approach.

The flight crew checks that:
- Deviation scales are displayed on the PFD
- The IDENT is properly displayed on the PFD.

”

Intermediate approach

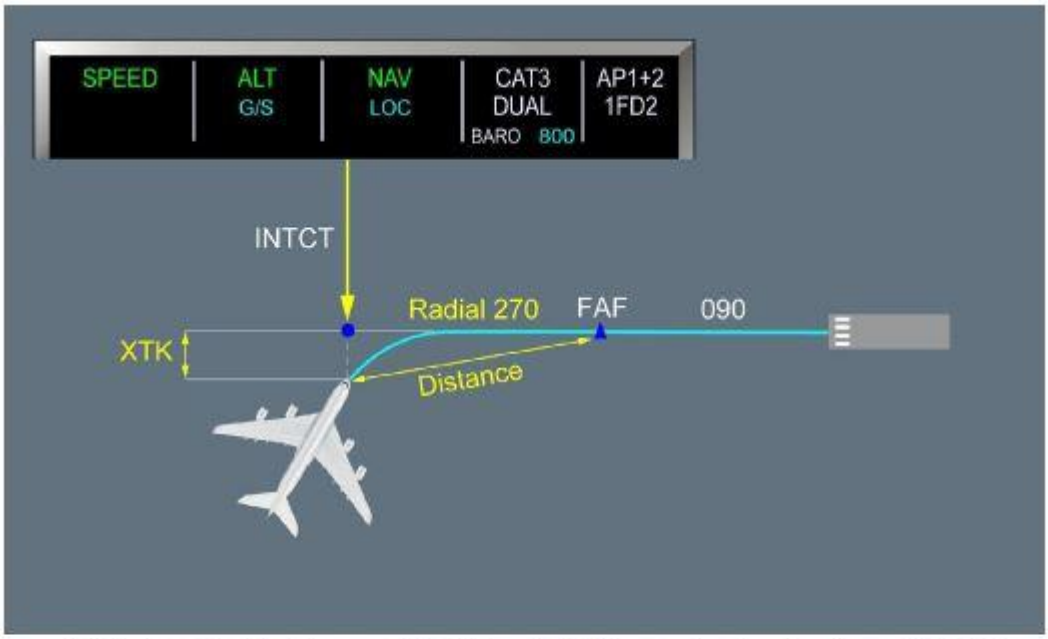
“

INTERCEPTION OF FINAL APPROACH COURSE

When cleared for approach, and when on the intercept of the approach lateral trajectory, the flight crew should press the APPR pb. This arms the approach mode and lateral and vertical approach modes are displayed in blue on the FMA. At this stage the second AP, if available, should be selected if the approach is an ILS.
The VV pb may be pressed, to display the small black bird, as a TRK/FPA information. It is particularly useful for crosswind or gusty conditions, to improve the situation awareness and smoothen the transition from instrument references to visual references.
If the ATC clears for a lateral capture only, the flight crew will press LOC pb on the AFS CP.
If the ATC clears for approach at a significant distance, e.g. 30 NM, the flight crew should be aware that the G/S may be disrupted and APPR1 will be displayed on FMA until a valid Radio Altimeter signal is received.
The AP uses the computed aircraft position versus the runway axis to smoothly capture the LOC, or F-LOC.

If ATC provides radar vectors, the flight crew uses the DIR TO COURSE IN function. This ensures:
- A correct F-PLN sequencing
- An appropriate ND display
- An assistance for lateral interception
- The VDEV to be computed on reasonable distance assumptions.

The final approach course interception in NAV mode is possible if NAV is PRIMARY or if the navigation accuracy check is positive.



When established on the lateral approach trajectory, the flight crew should not perform a DIR TO to sequence the F-PLN because this results in the FMS reverting to NAV mode, if the guidance mode is LOC or F-LOC. In this case, the LOC or F-LOC must be armed and captured again, unduly increasing the workload.
When the aircraft is cleared for the approach, the flight crew presses the APPR pb to arm the approach modes when applicable. ”

Final approach

“

GO-AROUND ALTITUDE SETTING

When established on final approach, the flight crew should set the go-around altitude on the AFS CP. This can be done at any time when G/S or F-G/S mode engages. However, for an approach with a selected guidance (either FPA or V/S), the flight crew must set the missed approach altitude only when the current aircraft altitude is below the missed approach altitude, in order to avoid inappropriate ALT* engagement.

REACHING THE MINIMA

The flight crew must decide to land or go-around at the minimum altitude at the latest. When the aircraft reaches the minimum altitude, at the MINIMUM callout:

- Continue and land if the appropriate visual references can be maintained and the aircraft is correctly established, or
- Go-around in all other cases.

The flight crew should not set the minimum altitude as the target altitude on the AFS CP, because it causes a spurious ALT* when approaching the minimum altitude, resulting in a destabilization of the approach at a critical stage.

AP DISCONNECTION

During the final approach with the AP engaged, the aircraft is stabilized. Therefore, when the flight crew disconnects the AP for a manual landing, they should avoid to make large inputs on the sidestick. The flight crew should disconnect the autopilot early enough to resume manual control of the aircraft and to evaluate the drift before the flare. During crosswind conditions, the flight crew should avoid any tendency to drift downwind.

Some common errors include:

- Descending below the final path
- Reducing the drift too early.

MISCELLANEOUS

Near the ground, avoid nose down corrections, the priority is attitude and sink rate.
For more information on the effect of failure during approach, *Refer to FCOM/DSC-22-FG-90-30 Autoland Warning*.

”

App-3.5 SOP for ILS Approach specificities according to the *FCTM*

The standard operating procedures (SOP) of the specificities of ILS approach according to the *Flight Crew Technique Manual* covers for CAT I ILS, and CAT II or CAT III ILS. Recommendations mentioned above for general approach apply.

For CAT I ILS, the flight crew should insert DA value in the BARO entry field of the APPR panel of the FMS ACTIVE/PERF page because that value is baro referenced.

For CAT II or CAT III ILS, the flight crew should insert DH value in the RADIO entry field of the APPR panel of the FMS ACTIVE/PERF page because that value is radio altitude referenced.

Initial approach

“

APPROACH PHASE ACTIVATION

For a standard ILS approach, the flight crew should plan a decelerated approach. However, if the G/S angle is greater than 3.5 ° or if forecast tailwind at landing exceeds 10 kt, an early stabilized approach is recommended.

”

App-3.6 SOP for Glideslope (G/S) interception from above according to the *FCTM*

The standard operating procedures (SOP) of the glideslope interception of an ILS from above according to the *Flight Crew Technique Manual* is as following:

"

GLIDE SLOPE INTERCEPTION FROM ABOVE

The following technique enables the flight crew to intercept the glide slope of an ILS from above, provided that the aircraft is already established on the localizer of the ILS.
There are a number of factors that can result in a G/S interception from above. In such a case, the flight crew must react without delay to reach the stabilization criteria. In order to achieve the best rate of descent when cleared by ATC and below the limiting speeds, the flight crew should extend the landing gear and select flaps as required, until final configuration in the case of very late descent. The flight crew can use the speed brakes, taking into account information detailed in the following chapter, *Refer to "Deceleration and configuration change".*

When cleared to intercept the glide slope, the flight crew should:
- Press the APPR pb on FCU and confirm G/S is armed. Monitor the vertical interception.
- Select the FCU altitude above aircraft altitude to avoid ALT* engagement.
- Select V/S -1 500 ft/min initially. V/S in excess of -2 000 ft/min will result in the speed increasing towards VFE.

It is important to use V/S instead of OP DES to ensure that the A/THR is in SPEED mode instead of THR IDLE mode. The flight crew should carefully monitor the rate of descent to avoid exceeding VFE.
When approaching the G/S, G/S* engages. The flight crew monitors the G/S capture with raw data (i.e. pitch and G/S deviation).
The flight crew sets the missed approach altitude on the AFS CP and reduces the speed in order to be configured for landing by 1 000 ft AAL.
In this situation, taking into account the ground and the obstacles, and if ATC permits, it may be appropriate to perform a 360 ° turn before resuming the approach.

"

App-3.7 SOP for Go-around according to the *FCOM*

The standard operating procedures (SOP) for go-around according to the *Flight Crew Operating Manual* prescribes the following aspects: go-around initiation, and at go-around acceleration altitude.

Go-around initiation

"

GO-AROUND INITIATION

For more information on considerations about initiation of go-around, *Refer to FCTM/PR-NP-SOP-210 Decision Making*

For additional information on the associated callouts:

- *Refer to PRO-NOR-SCO Summary for Each Flight Phase*
- *Refer to PRO-NOR-SCO Flight Parameters in Go-Around.*

Simultaneously apply the following three actions:

THRUST LEVERS ..... TOGA THEN FLX/MCT | PF

Set the thrust levers to the TOGA detent to ensure engagement of SRS GA mode. Then, set the thrust levers to FLX/MCT to engage the GA SOFT mode.
At any time, if TOGA thrust is desired, set the thrust levers to TOGA detent.

Note: If the thrust levers are not briefly set to the TOGA detent, the FMS does not engage the GO-AROUND phase, and when the aircraft flies over, or close to the airport (less than 7 NM) the FMS will sequence the destination waypoint in the F-PLN.

For more information on go-around phase:

- *Refer to FCTM/PR-NP-SOP-210 AP/FD Go-Around Phase Activation*
- *Refer to FCTM/PR-NP-SOP-210 Go-Around Phase.*

ROTATION ..... PERFORM | PF

Initiate the rotation toward a pitch attitude of 12.5 ° (10 °, if one engine is failed) to obtain a positive rate of climb, then follow the SRS pitch command bar.
If the go-around is performed with Auto Pilot (AP) check pitch increase.
When near to the ground, avoid excessive rotation rate in order to prevent a tailstrike.

GO-AROUND ..... ANNOUNCE | PF
FLIGHT PARAMETERS ..... MONITOR | PM

The PM must monitor flight parameters and announce any deviation. For more information on the associated callouts, Refer to PRO-NOR-SCO Flight Parameters in Go-Around.

If the PM announces a flight parameter deviation, the appropriate PF response must:

- *Acknowledge the PM callout, for appropriate flight crew coordination*
- *Take immediate corrective action to bring the parameter back into the defined stabilized conditions.*

FLAPS ..... RETRACT ONE STEP | PM
FMA ..... CHECK/ANNOUNCE | PF

If the FMA does not display MAN GA SOFT or MAN TOGA, immediately set the thrust levers to the TOGA detent.

POSITIVE CLIMB ..... ANNOUNCE | PM
L/G UP ..... ORDER | PF
L/G ..... UP | PM
NAV or HDG ..... AS RQRD | PF „

At go-around thrust reduction altitude (LVR CLB flashing on FMA)

“

AT GO-AROUND THRUST REDUCTION ALTITUDE (LVR CLB FLASHING ON FMA)

THRUST LEVERS.....CL | PF „

At go-around acceleration altitude

“

AT GO-AROUND ACCELERATION ALTITUDE

Monitor that the speed target increases to initial CLB speed. | PF

● **If the speed target does not increase to initial CLB speed:**

AFS CP ALTITUDE.....CHECK | PF
ALT pb.....PRESS | PF

For additional information on the associated standard callouts, *Refer to PRO-NOR-SCO Flaps or Gear Configuration.*

FLAPS.....ORDER RETRACTION ON SCHEDULE | PF
FLAPS.....RETRACT | PM
GND SPLRS.....DISARM | PM
EXTERIOR LIGHTS.....SET | PM
AFTER TAKEOFF/CLIMB C/L down to the line.....COMPLETE | BOTH

Refer to PRO-NOR-C-L After Takeoff/Climb

For additional information on the associated standard callouts, Refer to PRO-NOR-SCO Summary for Each Flight Phase.

● **If necessary, at the transition altitude:**

BAROMETRIC REFERENCE.....SET STD/CROSSCHECK | BOTH

- *At the transition altitude, the barometric setting flashes on the PFD. The flight crew should set STD on the EFIS CP and on the ISIS SFD*
- *Crosscheck the barometric settings and the altitude indications*
  For more information on the VD in relation to the barometric reference setting, Refer to FCTM/PR-NP-SOP-140 Vertical Display .
- *For additional information on the associated callouts, Refer to PRO-NOR-SCO Summary for Each Flight Phase.*

AFTER TAKEOFF/CLIMB C/L below the line.....COMPLETE | BOTH

Refer to PRO-NOR-C-L After Takeoff/Climb

For additional information on the associated standard callouts, Refer to PRO-NOR-SCO Summary for Each Flight Phase.

Fly the published missed approach procedure, or prepare for a second approach, or divert as required.

For more information on leaving the go-around phase, *Refer to FCTM/PR-NP-SOP-210 General.*

● **To fly the published missed approach:**
Engage the NAV or the HDG mode.
NAV, HDG, or TRACK modes can be engaged only above 100 ft.

● **When the flight crew established the aircraft path and obtained the clearance:**
The PF transfers his/her duties to the PM. | PF
The PF can request the PM to update the FMS, depending on the situation.
The following tasksharing remains the one decided since the beginning of the flight.

● **To prepare for a second approach:**
APPROACH PHASE..... ACTIVATE | PF-PM
Activate the APPR phase on the FMS ACTIVE/PERF page.

If the APPR phase is not activated :
- *Managed approach speed is not available*
- *BARO/RADIO indications do not appear on the PFD.*

● **To divert to the alternate:**
FMS ..... UPDATE | PF
- *If the flight crew prepared an alternate flight plan, they should use ENABLE ALTN in the revision menu of the TO waypoint on the ACTIVE/F-PLN page*
- *If the flight crew prepared a SEC/F-PLN to the diversion airfield, they should swap the SEC F-PLN to the ACTIVE F-PLN.*
- *If the flight crew did not prepare any alternate, they should:*
  - *Initiate a selected climb*
  - *Perform a lateral revision to insert the new destination.*

● **When cleared to a waypoint:**
DIRECT TO ..... PERFORM | PF
The FMS automatically reverts to the CLB phase.
The FMS automatically sets the CRZ FL at the default alternate CRZ FL (FL 100, FL 220, or FL 310), and maintains the previous cost index.
The flight crew may adjust these targets if necessary.

FMS..... CROSSCHECK | PM "

App-3.8 SOP for Go-around according to the *FCTM*

The standard operating procedures (SOP) for go-around according to the *Flight Crew Techniques Manual* prescribes the following aspects: consideration about the go-around, AP/FD go-around phase activation, go-around phase, and leaving the go-around phase.

Consideration about go-around

"

DECISION MAKING

The flight crew must consider to perform a go-around if:

- There is a loss or a doubt about situational awareness, or
- There is a malfunction which jeopardizes the safe completion of the approach or landing, e.g. major navigation problem, or
- ATC changes the final approach clearance resulting in rushed action from the crew or potentially unstable approach, or
- The approach is unstable in speed, altitude, or flight path in such a way that stability is not obtained by 1 000 ft AAL in IMC (500 ft AAL in VMC), or is not maintained until landing, or
- Any of the following alerts occur:
  - TAWS, or
  - TCAS, or
  - Windshear, or
  - ROW alerts for the relevant runway condition (e.g. "RWY TOO SHORT" for dry runway condition, "IF WET RWY TOO SHORT" for damp, wet or more slippery runway).
- Adequate visual references are not obtained at minima or lost below minima.

GO-AROUND NEAR THE GROUND

The PF must not initiate a go-around after the selection of the thrust reversers.
If the PF initiates a go-around, the flight crew must complete the go-around maneuver.

If the flight crew performs a go-around near the ground, they should take into account the following:

- The PF should avoid excessive rotation rate, in order to prevent a tailstrike. For more information, *Refer to PR-NP-SOP-220 Tail Strike Avoidance.*
- A temporary landing gear contact with the runway is acceptable.
- Only when the aircraft is safely established in the go-around, the flight crew retracts flaps one step and the landing gear.

Note: If the aircraft is on the runway and in FULL configuration when the PF applies TOGA thrust, a CONFIG FLAPS NOT IN T.O CONFIG ECAM alert is triggered. The flight crew should disregard this alert.

”

AP/FD go-around phase activation

“

When the thrust levers are set to the TOGA detent, and provided that the slats/flaps configuration is different from clean configuration, or the flap lever is not set to the 0 position, all of the following occur:

- The SRS GA and the GA TRK (NAV) modes engage
- The GA phase activates on the FMS:
  - The missed approach becomes the active F-PLN
  - At the end of the missed approach procedure, the FMS strings the previous flown approach in the active F-PLN.
- If not previously engaged, the FD automatically engages with the HDG/VS reference on the AFS CP

  For the go-around, the appropriate flight reference is the attitude, because go-around is a dynamic maneuver
- If extended, the speed brakes automatically retract.

To perform a soft go-around, the PF must set thrust levers to the TOGA detent to ensure engagement of SRS GA mode. Then, the PF must set the thrust levers to the FLX/MCT detent to engage the GA SOFT mode. In this case, the FMA displays MAN GA SOFT, and the AP/FD vertical and lateral modes remain engaged.
In GA SOFT mode, the SRS GA mode remains engaged with a vertical speed target of approximately 2 000 ft/min.

If the thrust levers are not correctly set to the TOGA detent (i.e. the full forward thrust levers position), the following occur:

- The AP/FD remains engaged in approach or landing mode (e.g. G/S, LOC, LAND, FLARE on FMA)
- The FMS does not engage the GA phase, and remains in APPR phase
- The FMA displays FOR GA : SET TOGA.

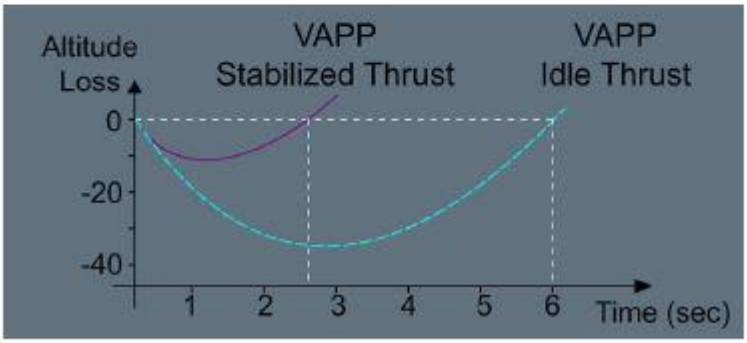
”

Go-around phase

“

The SRS mode guides the aircraft with a maximum speed of VAPP, or IAS at time of TOGA selection (limited to maximum of VLS + 25 with all engines operative or VLS + 15 with one engine inoperative) until the acceleration altitude where the target speed increases to the CLB speed.
The GA TRK mode guides the aircraft on the track memorised at the time of TOGA selection. The missed approach trajectory becomes the ACTIVE F-PLN provided the waypoints have been correctly sequenced on the approach. Thanks to the automatic arming of the NAV mode, the missed approach F-PLN is followed as soon as the NAV mode engages.
When the flight crew sets the thrust levers to TOGA or TOGA then FLX-MCT for go-around, it takes some time for the engines to spool up due to the acceleration capability of the high-bypass ratio engines. Therefore, the flight crew must be aware that the aircraft will initially lose some altitude. This altitude loss will be greater if initial thrust is close to idle and/or the aircraft speed is lower than VAPP.

Attitude Loss Following a Go-Around



Above the go-around acceleration altitude, the target speed is CLB speed.

”

Leaving the go-around phase

“

GENERAL

The purpose of leaving the go-around phase is to obtain the proper target speed and proper predictions depending upon the strategy chosen by the crew. During the missed approach, the flight crew will elect either of the following strategies:

- Fly a second approach
- Perform a diversion.

SECOND APPROACH

If a second approach is to be flown, the flight crew will activate the approach phase on the MFD ACTIVE/PERF page.
The flight crew will ensure proper waypoint sequencing during the second approach in order to have the missed approach route available, should a further go-around be required.

DIVERSION

Once the aircraft path is established and clearance has been obtained, the flight crew will enter the ALTN F-PLN as ACTIVE F-PLN:

- If the flight crew has prepared the ALTN F-PLN in the active F-PLN, on selecting the ENABLE ALTN prompt on the TO WPT revision menu, the lateral mode reverts to HDG if previously in NAV. The aircraft will be flown towards the next waypoint using HDG or NAV via a DIR TO entry.
- If the flight crew has prepared the ALTN F-PLN in one SEC F-PLN, the MFD SEC INDEX page will be accessed and SEC F-PLN for diversion will be swapped to active. The flight crew will use the DIR TO function as required to sequence the F-PLN.
- If the flight crew has not prepared the ALTN F-PLN, climb will be initially flown in OP CLB mode. Once established in climb and clear of terrain, the flight crew will use the “DIR TO” function to the next cleared waypoint, make a lateral revision at this waypoint to insert a NEW DEST and finalize the ALTN F-PLN. The route and a CRZ FL (on PERF page) can be updated as required.

”

Appendix 4. Post Flight Report (PFR)

CMS Data

PFR filter mode: Filters On - ABM54CMC012100U

CFR | PFR | Cockpit Alerts

Cockpit items | Cabin items | Pending items | Minor items

Item	Filtered	Fault tracking	Phase	Date Time	ATA	Source	Fault code	Title	Subtitle	Class	Occurrence History	Priority
1/4	No	!	01-PREFLIGHT	10 Sep 17 - 11:53	2851	FQMS 2	2851F7ZA	PANEL-INTEGRATED REFUEL(42QU)		1		
4/4	Yes	!	08-CRUISE	10 Sep 17 - 17:59	2270	FMC-A1	2270F3LN	AUTO RESET		0		
		!	08-CRUISE	10 Sep 17 - 17:59	3414	IR 1	3414F3K4	FMC-A(1CC1) / AFDX NETWORK		6		
		!	08-CRUISE	10 Sep 17 - 17:59	3414	IR 2	3414F73L	FMC-A(1CC1) / AFDX NETWORK		6		
		!	08-CRUISE	10 Sep 17 - 17:59	3414	IR 3	3414FAN2	FMC-A(1CC1) / AFDX NETWORK		6		
		!	08-CRUISE	10 Sep 17 - 17:59	2270	FMC-A1	2270F3JM	FMC-A(1CC1)		1		
			08-CRUISE	10 Sep 17 - 17:59	3455	VOR 1	3455F3JJ	FMC-A(1CC1) / IOM-A3(1TG3) / RMP-1(3RN1)		6		
		!	08-CRUISE	10 Sep 17 - 17:59	3436	MMR 1	3436F3JT	FMC-A(1CC1) / IOM-A3(1TG3) / RMP-1(3RN1)		6		
2/4	No	!	08-CRUISE	10 Sep 17 - 18:21	2780	SLATS 2	2780F8WB	FPPU-SLAT(27CW) / SFCC-2(22CV) / WRG TO SFCC-2(22CV),FPPU-SLAT(27C...		1		
			08-CRUISE	10 Sep 17 - 18:21	2780		2780W020	F/CTL SLAT CTL 2 FAULT				M
			08-CRUISE	10 Sep 17 - 18:21	2796	EFCS AFS 1	2796F0PR	SFCC-2(22CV)		5		
			08-CRUISE	10 Sep 17 - 18:21	2796	EFCS AFS 2	2796F0PR	SFCC-2(22CV)		5		
3/4	No	!	11-TAXI IN	10 Sep 17 - 18:32	2851	FQMS 1	2851F3PS	ELEMENT-APU FUEL PUMP(4QC)		1		
		!	11-TAXI IN	10 Sep 17 - 18:32	2851	FQMS 2	2851F788	ELEMENT-APU FUEL PUMP(4QC)		1		

Appendix 5. Operator's Crew Critical Information (CCI)

Russian Federation **MOSCOW** Domodedovo

CCI

27-APR-2017

DME-UUDD

C-01

Emirates

GENERAL

AD CAT:	**B**	H24	
RWY:	14L/32R (A380 N/A)	3794 X 53m	ILS CAT I/ ILS CAT III a
	14R/32L	3500 x 60m	ILS CAT III a/ ILS CAT I
D-ATIS:	No		
COMPANY:	JSC Domodedovo		
LOCAL TIME:	**UTC** +3		

CREW THREAT INFORMATION

ATC:

- Crews report non TCAS traffic sightings. ATC may not pass traffic information on non-transponder traffic in the Russian FIR's.
- Flight outside controlled airspace are prohibited, except to avoid extreme weather (request radar guidance).
- Prohibted area – Moscow city – NW of the airport.

APPROACH: (Metric)

- Russian altimetry in meters/QFE below TL.
- EK operate in feet/QNH below TL. Request QNH from ATC.
- Metric to feet conversions: Refer to tables on LIDO Charts.
- A380: No LVO RWY 32 (RWY 32L CAT I ILS only + RWY 32R not suitable).

RUNWAY:

- Lit highway between 14L & 14R, see AGC.

GROUND OPERATION:

- All runways reported as rough.

DEPARTURE: (Metric)

- Russian Altimetry in meters/QFE below TA.
- EK operate in feet/QNH below TA. Request QNH from ATC.
- Metric to Feet Conversions: Refer to tables on LIDO Charts.

ENVIRONMENT:

- Refer to Cold WX Ops for any altitude corrections.

Changes:

cci@emirates.com

Emirates (UAEPILOTS)

CCI

Russian Federation **MOSCOW** Domodedovo

27-APR-2017

C-02

DME-UUDD

Emirates

CHARTS – ARRIVAL

- B777: Default FMS codes a speed of 270 knots below FL100.
- RWY 14R/32L EK preferred RWY.
- RWY 14L/32R may be used by A/C other then A380.
- Low TL given by ATC. Update FMS default.
- Above TL clearances will be to FL/STD feet RVSM.
- Below TL clearances are in meters/QFE which must be converted to feet/QNH.
- ATIS (Russian and English) reported difficult to understand.

Warnings:

- See QFE to QNH conversion on LIDO STAR & IAC Charts.

Cautions:

- Pressure setting in METAR is QNH.
- Pressure setting in Moscow ATIS is QFE.

Notes:

- Control of flights within the TMA provided by ATC located at the ACC in Vnukovo. Secondary Approach (SAPP) for Domodedovo is based in the local Tower and only responsible for traffic below 1200 m (3900 ft).
- LIDO RM CRAR Russia/U states "Wind direction for LDG and TKOF degrees MAG for AD's with VAR of 5° or more".

STAR

- Expect FE 1D STAR transition, and AO STAR.
- If on radar vectors, expect no instructions for the last 90 degree turn on to Final, (ATC expect aircraft to establish onto Final without further instructions).

IAC

- ATC clearances in meters/QFE. EK aircraft operate in feet/QNH.

Arrival Risk Mitigation Strategies

- Altimetry: Request QNH from ATC & refer to conversions tables on LIDO Charts.
- Due to poor ATIS, consider confirming RWY in use on first contact with radar.

Changes: LVOPS MINIMA – Text amended.

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✓ Emirates (UAEPILOTS)